APPLIED MECHANICS Reviews

A CRITICAL REVIEW OF THE WORLD LITERATURE IN APPLIED MECHANICS AND RELATED ENGINEERING SCIENCE

REVS. 2753-3192 VOL. 12, NO. 6 JUNE 1959

GENERAL

Analytical Methods in Applied Mechanics 380
Computing Methods and Computers 381
Analogies 382
Kinematics, Rigid Dynamics and Oscillations 382
Instrumentation and Automatic Control 385

MECHANICS OF SOLIDS

Elasticity 386
Viscoelasticity 388
Plasticity 389
Rods, Beams and Strings 392
Plates, Shells and Membranes 393
Buckling 395
Vibrations of Solids 396
Wave Motion and Impact in Solids 398
Soil Mechanics: Fundamental 399
Soil Mechanics: Applied 400
Processing of Metals and Other Materials 401
Fracture (Including Fatigue) 402
Material Test Techniques 404
Properties of Engineering Materials 404
Structures: Simple 406
Structures: Composite 409
Machine Elements and Machine Design 409
Fastening and Joining Methods 410

MECHANICS OF FLUIDS

Rheology 410
Hydraulics 412
Incompressible Flow 413
Compressible Flow (Continuum and Noncontinuum Flow) 414
Boundary Layer 416
Turbulence 418
Aerodynamics 418
Vibration and Wave Motions in Fluids 420
Fluid Machinery 420
Flow and Flight Test Techniques and Measurements 422

HEAT

Thermodynamics 423
Heat and Mass Transfer 424
Combustion 426
Prime Movers and Propulsion Devices 427

COMBINED FIELDS AND MISCELLANEOUS

Magneto-fluid-dynamics 427
Aeroelasticity 428
Aeronautics 429
Astronautics 429
Acoustics 429
Micromeritics 430
Porous Media 432
Geophysics, Hydrology, Oceanography, Meteorology 433
Naval Architecture and Marine Engineering 438
Friction, Lubrication and Wear 439

Books Received, 440

Turbulence Measurements, Leslie S. G. Kovasznay, 375

Published Monthly by THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS at Easton, Pa., and edited by Southwest Research Institute with the co-operation of Linda Hall Library.

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Subscription and Production Office: **The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., U. S. A.**

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APPLIED MECHANICS REVIEWS, June 1959, Vol. 12, No. 6. Published Monthly by The American Society of Mechanical Engineers at 20th and Northampton Streets, Easton, Pa., U. S. A. The editorial office is located at the Southwest Research Institute, San Antonio 6, Texas, U. S. A. Headquarters of ASME, 29 West 39th St., New York 18, N. Y., U. S. A. Price $2.50 per copy, $25.00 a year. Changes of address must be received at Society headquarters seven weeks before they are to be effective on the mailing list. Please send old as well as new address. . . . By-laws: The Society shall not be responsible for statements or opinions advanced in papers or printed in its publications (B13, Par. 4). . . . Entered as second-class matter, January 11, 1948, at the Post Office at Easton, Pa., under the Act of March 3, 1897. ©Copyrighted, 1959, by The American Society of Mechanical Engineers.

APPLIED MECHANICS REVIEWS

VOL. 12, NO. 6 MARTIN GOLAND *Editor* JUNE 1959

TURBULENCE MEASUREMENTS

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INTRODUCTION

The phenomenon of turbulence plays an important role in fluid mechanics. It appears that all flow configurations containing solid boundaries become turbulent above some value of the Reynolds number. Theoretical considerations also indicate that the nonlinearity of the governing hydrodynamic equations is necessary in producing turbulence.

The different theoretical approaches to this problem in the past have contained quite a few heuristic elements, so the role of experimentation has always been quite important. This is in contrast to many other branches of applied mechanics where experimentation is needed more to verify or disprove theories than merely to explore. Even today, in turbulence research one needs experiments for "inspiration" since our common sense so often fails us in the discovery of important relationships.

The subject of our discussion is a survey of the measuring techniques now used to discover the properties and dynamic structure of turbulent flows. In a short article we must confine our attention to methods, and we shall deal with no experimental results. Of all the instruments the most important tool is undoubtedly the hot-wire anemometer. Other instruments and measuring methods have often been considered, but so far none of them has seriously challenged the pre-eminence of the hot-wire method. Before embarking on a detailed discussion of the hot-wire technique, however, let us consider briefly the other existing methods.

METHODS OTHER THAN THE HOT-WIRE ANEMOMETER

Flow visualization can be a very effective tool for studying relatively orderly flow phenomena, such as Karman's vortex streets, or the roll-up vortices attached to wing tips, but it has not been very successful for studying turbulence. One of the most striking properties of turbulence is its random, irregular nature. As every experimenter learns sooner or later (present author not excepted) one cannot spot a "typical eddy" in turbulence. On the contrary there is a continuous range of configurations and it appears more and more convincingly that only statistical averages can give adequate quantitative description of the phenomenon.

Diffusion techniques offer more possibilities. Transport of heat or of an alien species of molecule is greatly increased by the presence of turbulence compared with that due to normal molecular diffusion. The increased diffusion was exploited by several experimenters [Schubauer (68), Westenberg (89), Prudnikov (61)]. The diffusion from a point or line source placed in the flow field can be conveniently observed by placing a heated wire (68) in the flow. Injecting helium (89) or sodium vapor (61) at a point also forms a wake containing an alien substance. A second probe then surveys the spreading of the wake, and the effective turbulent diffusion coefficient can be determined. The theoretical basis of this technique rests on G. I. Taylor's early paper (79).

Optical techniques used in studying supersonic flows can be adapted to measure turbulent density fluctuations. In the case of high-speed air flow, especially in supersonic wakes and jets, the density fluctuations can be quite important. With short-duration spark photography (1 microsecond exposure or less), good quality shadow pictures of turbulent regions are obtainable. Statistical processing of the shadow pictures can yield important variables such as the microscale of the density fluctuations (36), (84), (85), but the method is laborious and not very sensitive; so in general, it has had only a secondary role.

In most flows, the optical wavelength (order of 0.00005 cm) is very short compared to the scale of turbulence. By choosing the wavelength of the electromagnetic radiation to be at least of the same order of magnitude as the turbulence scale, we obtain the interesting possibility of using microwaves to study large-scale phenomena such as atmospheric turbulence. The problem of transhorizon propagation of the microwaves by scattering them on the atmospheric turbulence brought this possibility into focus [Bolgiano (6)].

The more direct measuring methods attempt the measurement of instantaneous values of turbulent fluctuations (velocity, density, pressure, temperature) at a point, by introducing a sensitive probe and processing the electrical signal later by statistical methods. The hot-wire has proved so far to be the most successful of these, although there are other competing methods, such as the electric discharge anemometer and the electromagnetic flowmeter. The first exploits the fact that an electrical "glow discharge" or "dark current discharge" can be strongly influenced by the air flow between the electrodes. Both d-c [Werner (90), (91), (92)] and high frequency a-c [Vrebalovich (88)] discharge anemometers were developed by experimenters, and the work was actually carried to such a degree of perfection that it began to compete with the hot-wire anemometer. The electromagnetic flowmeter can best be used in liquids of high conductivity. A strong magnetic field oriented across the mean flow creates an electric field perpendicular both to the magnetic field vector and to the flow velocity vector due to the transport of ions. The potential difference thus created can be picked up by

shielded electrodes [Grossman (30)]. The principal advantage of the method is the simplicity of its principle and the linearity of response to flow velocity. The main disadvantages are the inconvenient configuration (large magnets are necessary) and the high electrical impedance of the probes. In practice the magnetic flowmeter was most successfully used to study pipe flow where the magnet could be placed outside the pipe.

THE HOT-WIRE ANEMOMETER

The hot-wire anemometer is the principal tool of turbulence research today and it must be stated right away that even this one is far from being an ideal instrument. Nevertheless, most of the reliable experimental information we have on turbulence has been obtained with the hot-wire anemometer and the other methods have only given indications that they can supply data that is not in disagreement with the hot-wire data.

The working principle is the following. A thin metallic wire (typical diameter 0.0001–0.001 cm, length 0.05–0.5 cm, material platinum, tungsten or other metals) is heated by an electric current (typically 20–200 mA) above the ambient temperature of the air (10°–500°C). In steady state, the thermal equilibrium of the wire represents a relationship between the electrical and hydrodynamic variables such as temperature attained and the heating current imposed, and of the flow variables such as air temperature, air density, air velocity. This functional relationship can always be determined at least in principle by a detailed static calibration. Fortunately, the functional form of this relationship is reasonably well-known and when expressed in nondimensional form it is quite reliable. For the purpose of turbulence measurement, there is also a practical consequence: one needs to determine only a few numerical constants and there is no need to prepare detailed calibration "maps" by varying several variables.

It must be emphasized that in general the hot-wire anemometer is not a good instrument to measure mean velocity or mean temperature since the sensitivity and reproducibility are both inferior to those of other conventional instruments. The pitot-tube liquid manometer combination for mean velocity measurement and the shielded thermocouple for temperature measurement are both far superior to hot-wire probes. The only exceptions where the hot-wire is superior for mean velocity measurements are, on one hand, measurements at very low velocities (5–50 cm/sec) and, on the other hand, measurements in high velocity gradient shear flows where the small physical dimension of the hot-wire offers less disturbance than even a flattened hypodermic tube. The unique advantage of the hot-wire is its fast time response, and the simple fact that its transient response can be made adequate up to very rapid fluctuations both in velocity and in temperature. In this respect the hot-wire anemometer is even more satisfactory than most microphones. If the static thermal equilibrium of the heat wire is disturbed by changing the velocity or the temperature, the transient response obeys a very simple differential equation.

The hot-wire anemometer as a measuring instrument is used essentially in one or the other of two principal modes of operation. If the heating current of the wire is kept constant and the variations in wire temperature are detected as fluctuations in the voltage drops across the wire, this is called constant current operation. Thermal energy is absorbed in the mass of the wire and is released again according to the fluctuating heat-transfer rate of the wire's thermal capacity. The thermal capacity when divided by the mean heat-transfer rate gives a quantity with dimension of time: this is the thermal time constant. The transient response at the particular operating point obeys the relatively simple differential equation

$$T + M\frac{dT}{dt} = T_{ST}(I, U, \rho, T_{AIR}) \qquad [1]$$

where T is the instantaneous temperature of the wire, M is the time constant of the wire at the particular operating point, T_{ST} is the temperature the wire would have attained if it responded instantly according to its static calibration, I is the heating current, U the velocity, T_{AIR} is air temperature, ρ is density. It is clear from Eq. [1] that electronic compensation of the thermal lag is relatively easy. It consists of adding to the hot-wire signal a certain amount of its first time derivative, the coefficient being the value of the time constant.

A constant current hot-wire anemometer consists of a d-c heating circuit, metering circuits for convenient determination of the static characteristics and high sensitivity, low input level amplifiers that also incorporate the thermal lag compensation. This scheme of operation is due to Dryden and Kuethe, et al (21) (22). It was independently discovered by Ziegler (100) and (101). A more recent version is found in (39) giving high frequency response up to 70 kc.

The other important mode of operation is the constant-temperature feedback system first proposed by Ziegler (102) and Weske (93) and analyzed in detail by Ossofsky (58). In this case approximately constant wire temperature is maintained at all times, therefore the thermal lag is made nonoperative. Since the wire temperature is not permitted to change there is no variable amount of energy stored in the thermal capacity. In order to achieve a constant temperature, the heating current must be varied rapidly according to the changing demands for heating. In practice the wire is placed in a Wheatstone bridge and the unbalance voltage appearing across the bridge is first amplified with the resulting large signal being used to control the heating current of the wire. This represents a strong negative feedback and it maintains the wire at a relatively constant temperature. The thermal lag effects are reduced in the ratio of the negative feedback applied (in practical cases this varies between 30 and 300).

Both systems, the constant-current system with electronic compensation (open loop) and the constant-temperature, negative feedback system (closed loop) have different merits and the preference of one over the other is dependent upon the particular application.

The sensitivity of the hot-wire anemometer to velocity fluctuations and to air temperature fluctuations depends on the partial derivatives of the heat loss function with respect to these flow variables. The first systematic study of the heat loss, both theoretically and experimentally, was by L. V. King (31). He found that the heat loss is approximately proportional to the temperature difference between air and wire and that it is a linear function of the square root of the velocity product.

$$\text{Heat Loss} = (T - T_{AIR})(A\sqrt{\rho U} + B) \qquad [2]$$

Later works have extended our knowledge in different directions. On the theoretical side, most recently Tomotika (80) recomputed the low Reynolds number case in incompressible flow. Compressibility effects have been of obvious interest. The first paper was by Tsien and Finston (83), later ones by Wu, Cole and Roshko (99), (9), (10), and independently by Tchen (78). Experimental work to extend the validity of the heat loss formulas to compressible regime was reported by Lowell (48) using rather thick wires intended primarily for measuring mean flow at transonic and supersonic Mach numbers. Kovasznay and Tornmarck (37)(38) found that, for supersonic flow, the heat loss data correlated well and if presented in a particular form are independent of the Mach number when the stagnation viscosity and heat conductivity are used to form the nondimensional variables. The entire transonic and supersonic range was also measured by Spangenberg (74) and a very careful detailed measurement of the supersonic heat loss was done by McClellan (52), (42). Slip flow and free molecular flow effects both become important for the wire

much before they become important for the wind tunnel as a whole since the wire diameter is so small compared to the rest of the apparatus. Baldwin (2), Collis (11), (12), (13) and Stalder, et al (75) have done the most important work. Hypersonic boundary-layer flow was probed by the hot-wire by Demetriades (17). Relatively new data on transonic behavior including nonlinear behavior with temperature difference (overheating) is reported by Stine and Winovich (77), (94).

On the opposite end of the scale, the validity of King's law at very low velocities is affected by free convection. In connection with this aspect of hot-wire application, Mahony (50), Simmons (73) and Van der Hegge Zijnen (87) should be mentioned. Using the hot-wire at very high temperature, Glawe (29) brings in a re-examination of the temperature dependence of heat loss. The use of the hot-wire in other media, especially in water, was explored by some workers. However, this idea was not pursued to a degree of perfection comparable with that attained in air. Richardson's early work (62), then Stevens and Borden (76) and Patterson (59) have reported on this application.

If the wire is not normal to the flow, the heat loss further depends on the angle of attack. As a rough approximation, the velocity component normal to the wire can be taken as the effective velocity to be substituted in King's formula [Eq. 2]. Detailed measurements modify this somewhat naive picture and Gaudfernau (27)(28) and Sandborn and Laurence (67) have more up-to-date information.

The presence of a solid wall near the wire naturally modifies the heat loss. This effect is quite important when measuring a boundary layer close to the wall. The simplest way one can guess the effect is by the use of images. Piercy and Richardson (60), (63) give details on this subject. Other spurious effects such as humidity in the air were also considered [Schubauer (69)].

In most practical cases the d-c voltage drop across the hot-wire is of the order of 0.5-1 volt. When the heating current is constant the voltage fluctuations caused by the velocity fluctuations are of the order of 1-5 millivolts for a turbulence level of one percent (using a typical overheating). As turbulence levels vary from a low value of 0.02-0.1 percent in the free stream of a low turbulence tunnel to 1-2 percent behind grids and finally 10-15 percent in turbulent boundary layers, the electric signals also vary from 50-100 microvolts up to 50-100 millivolts.

The hot-wire also responds to temperature fluctuation as would any resistance thermometer. The relative sensitivity for velocity and temperature fluctuations varies quite markedly with change of the overheating (typically in ratio 1:10 over the practical range) and this feature makes possible the separation of the velocity and temperature fluctuations in heated low-speed flows [Corrsin (15), (16)], and in compressible flows [Kovasznay (38), (40)].

The velocity component perpendicular to the mean flow can be sensed as fluctuation in the wire's angle of attack and the standard technique is to use two oblique wires so that with a variation of direction the angle of attack increases on one and decreases on the other (X or V probe). The configuration can be calibrated against the angle of flow simply by rotating the probe in a fixed airstream. The sensitivity for the v' or cross-component of the velocity appears to be of the same order of magnitude as the u' component directed along the mean flow. By combining the sum and difference of the u' and v' signals, Reynolds stress $\rho\overline{u'v'}$ can be measured. The analysis of errors due to the unavoidable mismatch of the two wires in this case becomes quite involved. Ashkenas (1), Ruetenik (64), (65), Newman & Leary (57) have dealt with this problem considering the low-speed case. In supersonic flow, Morkovin and Phinney attempted to do the same (55). Besides two-wire probes for measuring u' and v', more complex configurations exist for other purposes. A tetrahedral array of four wires can be arranged for the direct measurement of the vorticity component along the mean flow (41, on pages 227-228).

In high-speed flow the unheated hot-wire assumes a temperature that is close to the stagnation temperature, the actual value depending slightly on the Mach number and also on the Reynolds number (as we approach slip flow) (37), (38), (42), (52). The heat loss depends primarily on the mass flow ρU and the Mach number has important influences only in the high subsonic and transonic range. There is also a marked nonlinearity with overheating that affects significantly the fluctuation sensitivity coefficients.

In a well-established supersonic flow ($M > 1.2$) the procedure for separating the different fluctuation modes is well established (40), (54), (32). In high subsonic flow, however, the requirements on static calibration are so stringent that unambiguous interpretation of fluctuation measurements is much more difficult (54), (55).

The choice between a constant-current and a constant-temperature system depends mainly on the intended field of application. When the fluctuations are large ($u'/U > 0.10$ or if the velocity is allowed to drop to a value near zero, the constant-temperature system is definitely superior. On the other hand, if the separation of velocity and temperature fluctuations is important (this includes practically all supersonic work) constant-current operation is necessary, for measurements must be taken at a variable amount of overheating down to vanishing heating currents. Since the constant-temperature feedback system can operate successfully only at relatively high overheating (the feedback ratio is directly proportional to overheating), it cannot be used at the low overheating needed for high-speed flow application. Turbulence measurement in a shock tube is an exception, being much more convenient with a constant-temperature system since it permits relatively strong overheating of the wire behind the shock by using instantaneous heating current values that would normally burn the wire in the still air before the shock front arrives.

The dynamic response of the wire, of course, depends on the thermal capacity and on the actual cooling rate. Dynamic calibration techniques exploit the fact that for small perturbations the time constant of the transient response must be the same for all kinds of imposed fluctuations, irrespective of whether the equilibrium is disturbed by transients in the heating current or in the velocity (18), (41). The dissenting view stresses the importance of finite heat conductivity effects along the wire [Betchov (3), (4)]. Such questions can be settled experimentally. Mechanical shaking of the wire in a uniform steady flow has often been suggested, but a high frequency cannot be reached without excessive inertial forces in the wire. Square wave heating current transients were first adopted by present author (33) as a routine method of time constant calibration. Comparison of response at two discrete frequencies is also feasible (66). An excellent aerodynamic step-form transient can be created in the form of a traveling shock wave in a shock tube and this was used to verify the theory of transient response [Dosanjh (19), (20)]. Typical hot-wire time constants are of the order of $0.1\text{-}2.0\ 10^{-3}$ sec. (increasing with diameter and overheating). The use of coated quartz fibers and other laminated structures were considered by Lowell (49), Borden (7) and Ling (47), giving a more suitable system, especially in water. In accordance with the time constant values above, the unaided wire gives a uniform frequency response up to 1600 cps or 80 cps respectively (3 dB point). Electronic compensation of the thermal lag needs an extra amplification for the high frequencies at least by the same factor as the frequency band is being extended. The amplifiers have noise and ultimately this noise limits the minimum detectable turbulence signal. The point where the turbulence signal disappears in the thermal noise occurs at a turbulence level of the order of 0.1-0.2% $(u'/U) = 0.1 \div 0.2 \times 10^{-3}$. (Naturally, this depends on bandwidth and wire, and with great care it can be improved by another factor of 10.)

Obviously, the ultimate limit would occur when the thermodynamic noise (Johnson noise) of the hot-wire itself is reached, and dominates all other noise. Good quality hot-wire equipment today is within less than one factor of 10 from this ultimate limit. A moderate amount of thermal lag compensation can be accomplished by using mismatched transformer coupling ["poor man's hot-wire" (35), also Shepard (72)]. This has been used to compensate thermal lag of thermocouples.

Constant-current equipment in general has a lower noise figure (more freedom in tailoring the pass-band and also the added possibility of using transformer coupling [Schuh (70)]). Constant-temperature system, on the other hand, adapts itself well to transistorized circuitry and can be quite compact. (Present author will have a forthcoming publication elsewhere on miniaturized, transistor hot-wire circuits.) Since constant temperature circuitry also has a d-c response it is not too difficult to provide analogue circuitry for King's formula (two squaring circuits with a d-c offset bias) and a linearized output can be accomplished (43), (44), (58). A Carrier frequency (r.f.) operated constant temperature feedback system also can be attractive in some special applications, Tournier (81) and Shepard (71). A very detailed treatment covering all possible modes of operation (constant temperature, current, r.f. Carrier, etc.), mostly from the electronic engineer's point of view, is given by Wise, et al (95), (96), (97), (98).

The signals obtained from the hot-wire are processed further just as any other electrical signal. Historically they were hot-wire turbulence signals that were first processed to obtain statistical quantities such as autocorrelation and power spectra. Mean square quantities (turbulence level) are most often measured by the vacuum thermocouple, mean products for correlation measurements by the quarter-square method as the difference between the mean square of the sum and the mean square of the difference of the two signals. Triple and quadruple correlations have their corresponding analogue circuitry, Townsend (82).

In order to obtain the autocorrelation function, the short-time approximate steadiness of the turbulent pattern is used, and the fluctuations are measured at two different points in space while the results are interpreted as representing two different times. The frequent practice to interchange space and time variables in homogeneous turbulence is referred to as Taylor's hypothesis. Justification for this practice is based partly on intuition but also on a paper by Lin (46).

True time correlations, especially the combined space-time correlation, can be obtained by delaying one of the signals by the use of a magnetic tape-recorder. This approach has been most profoundly pursued by Favre, et al (23), (24), (25).

Power spectra are measured by narrow band filters followed by mean square instruments and the Fourier transformation properties of power spectra and autocorrelation functions can be verified.

In addition to the r.m.s. fluctuation representing turbulence level, different length scales are often determined. In principle these can be obtained equally well from the correlation or from the spectrum measurements. An interesting short-cut should be mentioned. This is the determination of the micro-scale λ by counting the number of zero crossings of the signal [Liepmann (45)]. In recent years the use of analogue computing techniques has become more common, so we do not need to deal here at length with the details of statistical processing of hot-wire signals.

The hot-wire has a finite length and the difference in the turbulent pattern at the two ends of the wire may significantly modify our statistical measurements. Wire length effects were estimated by Frenkiel (26) and a generalized treatment of statistical measurement with a probe of finite dimension is given in (85).

So far as special applications are concerned, no references are given here to papers that report mainly measured results, as the number of references on technique alone is already too high. For a general introduction, (41) would serve and (8), (21), (22), (86) and (87) all have historical value. Modern constant-current equipment is treated in (39) and (56); constant-temperature equipment in (34), (58) and (44). For the use of hot-wires in transonic and supersonic flow, (40) and (54) are useful. The subject of hot-wires in water is treated in (59) and (76), that of hot-wires in shock tube in (5), (19) and (20). Meteorological applications are given in (53).

We may sum it up the following way. During the 30 years of hot-wire turbulence research [counted from the Dryden and Kuethe report (21)], the improvement in technique is impressive and the published data on turbulence have increased steadily. Nevertheless, it still has more the caprice of an art than the complete reliability of a convenient routine laboratory procedure.

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Analytical Methods in Applied Mechanics

(See also Revs. 2758, 2767, 2771, 2772, 2774, 2779, 2782, 2784, 2810, 2966, 3013, 3028, 3034, 3048, 3071, 3126, 3135)

Book—2753. Flugge, S. (edited by), Encyclopedia of Physics, Mathematical methods I [Handbuch der Physik, Mathematische Methoden I], Berlin, Springer-Verlag, 1956, vii + 364 pp.

This book is an excellent reference work on the fields of mathematics in constant demand by the physicist and engineer. If used in conjunction with Vol. 2, it will provide information of value on most topics. It is also provided with a good bibliography and index. The following summary of the contents of Vol. 1 indicates the topics treated.

Chapter 1—The foundations of classical analysis (by J. Lense) covers differential and integral calculus, functions of a single real variable, functions of several real variables, infinite series, functions of a complex variable, conformal representation, ordinary differential equations and the Lebesgue integral.

Chapter 2—Partial differential equations (by J. Lense). The greater part of the chapter is concerned with partial differential equations of the first order and gives a good survey of the classical work of Lagrange, Cauchy and Jacobi. A section is given on contact transformations and the Hamilton-Jacobi equation. The section on partial differential equations of the second order is too compressed to be helpful.

Chapter 3—Elliptic functions and integrals (by J. Lense). An account is given of the properties of the elliptic functions of Weierstrass and Jacobi considered as functions of a complex variable z, of their inverses as elliptic integrals. The chapter concludes with a section on Theta functions.

Chapter 4—The special functions of mathematical physics (by J. Meixner). This chapter includes an account of the hypergeometric function, Bessel functions, Legendre functions and associated Legendre functions, the confluent hypergeometric function (Hermite and Laguerre polynomials, Whittaker functions), together with the associated differential equations and integral representations. Sections are included on differential difference equations, solutions of the wave equation involving products of special functions, and Mathieu functions.

Chapter 5—Boundary problems (by F. Schloegl). The account given in this chapter begins with a section on function spaces and Fourier series. Integral equations and their related orthogonal functions and eigenvalues follow; all the standard types are considered. The next section is on the calculus of variations and gives an account of the relation to differential equations and boundary problems.

Second-order partial differential equations are considered and a survey is given of hyperbolic, parabolic and elliptic types together with the standard methods of solution. The use of differential equation theory and the calculus of variations is considered in the determination of eigenvalues. The chapter closes with some account of the asymptotic determination of eigenvalues, and of the propagation of wave motion.

J. M. Jackson, Scotland

Book—2754. Kaplan, W., Ordinary differential equations, Reading, Mass., Addison-Wesley Publishing Co., Inc., 1958, xv + 534 pp. $8.50.

This treatise is an excellent introduction to ordinary differential equations. It deals thoroughly with all the standard methods of integration, but in addition places special emphasis upon methods for studying the properties of the integrals without the intervention of explicit formulas. Input-output analysis is given a prominent place and a thorough study is made of the general configuration of solution curves by means of phase-plane analysis.

The interest of the student is clearly uppermost in the author's mind. The existence of solutions is shown first of all by numerical and graphical means, and it is only in the last chapter that rigorous proofs are given, when doubtless their significance will be more fully appreciated. The illustrative problems are taken from a wide field; mechanics, electricity, chemistry, heat, elasticity, biology and economics are all represented, and the wide application of the theory as well as its debt to modern developments in the general field of systems analysis is emphasized. A large collection of illustrative exercises is included, together with answers placed at the end of each group of exercises, rather than in the usual relatively inaccessible position at the end of the book. The student will also be helped by the section which reviews methods for obtaining the roots of algebraic equations, by the appendix on the use of matrices and the chapter on numerical methods, which should perhaps have been more extensive in view of its great practical importance, which the author does indeed emphasize.

Some readers will be disappointed by the small part played by Laplace transforms, but no one will be dissatisfied by the thorough development of the method of the operator D.

This book is an excellent textbook, as well as a useful refresher course for those whose training in differential equations is dated. It should also be of great value to practicing engineers who are seeking to sharpen their mathematical tools.

W. S. Hemp, England

2755. Durstine, R. M., and Shaffer, D. H., Determination of upper and lower bounds for solutions to linear differential equations, *Quart. Appl. Math.* **16,** 3, 315–317 (Notes), Oct. 1958.

2756. Collatz, L., Error estimation in boundary-value problems of differential equations of infinite domain (in German), *ZAMP* **9a,** 2, 118–128, July 1958.

Types of boundary-value problems of partial differential equations for finite domains are discussed which can easily be transformed in such a manner as to allow estimations of error (for approximate solutions) similar to the boundary maximum principle. First, second and third boundary-value problems for the outer domain of linear elliptic and certain linear and nonlinear parabolic differential equations are examined. For elliptic differential equations one of the results is that the second boundary-value problem for more than two dimensions can be included. The estimates of the paper can thus be applied to problems of flow around some object, not in the case of two but of three dimensions. This is in a certain sense a counterpart to the conformal mappings method which is successful for two but not for three dimensions. Numerical examples show that estimations of error can easily be carried out.

From author's summary by R. C. Roberts

2757. Bellman, R., Some new techniques in the dynamic programming solution of variational problems, *Quart. Appl. Math.* **16,** 3, 295–305, Oct. 1958.

Previous papers of the author on dynamic programming have shown that a numerical solution of a problem in N state variables depends upon computations of sequences of N variables. This shortcoming can be overcome for a large class of linear problems; the restraints may be nonlinear. Author indicates how a number of multidimensional problems can be reduced to sequences of problems involving functions of but one variable. The reduction permits the methods of dynamic programming to be applied to the solution of large-scale problems in engineering and economics (terminal controls, time-lag processes, heat-conduction processes in nuclear reactor control). Detailed discussions of several matters will be treated in subsequent papers.

F. V. Pohle, USA

Computing Methods and Computers

(See also Revs. 2754, 2756, 2757, 3013, 3070, 3071, 3089, 3177)

2758. Keller, H. B., On some iterative methods for solving elliptic difference equations, *Quart. Appl. Math.* **16,** 3, 209–226, Oct. 1958.

The search for the most rapidly converging in a class of possible iterative methods begun by D. Young [*Trans. Amer. Math. Soc.* **70,** p. 92, 1954] is extended to larger classes. Which method is best depends on the eigenvalues of an associated matrix. The best methods are exhibited, for Laplace's equation in a rectangle, to be "extrapolated line-Liebmann or Gauss-Seidel" methods in which new values of the unknown at all mesh points on each line are found simultaneously by an appropriate over-relaxation involving the latest values available. If the mesh is itself rectangular, the line should be in the direction of the larger spacing. Author remarks that a method with fewest iterative steps may not be one with fewest operations.

C. M. Ablow, USA

Book—2759. Livesley, R. K., An introduction to automatic digital computers, New York, Cambridge University Press, 1957, viii + 53 pp. $1.75.

An interesting account of some computing procedures in automatic digital computers, written for the engineer who wants to decide whether or not such a computer will be useful to him. Specific circuits and mechanisms are touched lightly and only to give the reader a feel for the devices.

Chapter 1 deals with the basic concepts in simple program construction, with illustrative instruction codes, comparable to those found in the small commercially available electronic computers. Chapter 2 introduces the reader to machine components; various mechanisms for storing, entering and extracting data are mentioned. Chapter 3 explains somewhat more advanced ideas in the programming, such as the development of subroutines, program errors, and automatic programming. Chapter 4 treats briefly the problem of evaluating the usefulness of a computer in terms of repetitiveness, and type of mathematics involved. Mention is made of ordinary and partial differential equations, ray-tracing, linear programming, and tabulation.

While the reader could hardly decide on buying a computer without further investigation, Livesley's book seems to provide a good starting point.

G. R. Stibitz, USA

Courtesy of Mathematical Reviews

2760. Ramachandran, G. N., and Krishnamurthy, E. V., "Lilavati"—A new analogue computer for solving linear simultaneous equations and related problems. Pt. I. General principles and design of model I, *Proc. Indian Acad. Sci.* (*A*) **48,** 3, 152–164, Sept. 1958.

Problem is to solve a set of n linear equations with n unknowns. In conventional analog systems, a term such as $a_{mn}\,x_n$ is built with a potentiometer, where x is the voltage applied and a_{mn} the ratio determined by setting the wiper. In proposed system x_n is a current and a_{mn} is a resistance.

Authors obtain improved accuracy because each cell is less responsive to load variations than in conventional cases.

Proposed system seems new and workable, although authors do not explain how voltage error signals given by each equation are used to generate currents that represent the x_n.

J. M. Loeb, France

2761. Fisher, M. E., Stability and convergence limitations on the use of analogue computers with resistance network analogues, *Brit. J. Appl. Phys.* **9,** 7, 288–291, July 1958.

Various practical methods have been described for solving partial differential equations such as $\nabla^2\phi = f(\phi)$ by means of resistance networks coupled to electronic analogue computing units. These schemes are investigated mathematically to determine the conditions for which the computer remains stable, or for which the successive approximations converge to the required solution. It is shown that all the methods will break down if the gradient $df/d\phi$ is negative and sufficiently large to cause the correct solution to be "wave-like." From author's summary

Analogies

(See also Revs. 3070, 3117)

2762. Roots, O. T., The electrical simulation of crossed beams (in Russian), *Trudi Tallinsk. Politekhn. In-ta* (*A*) no. 65, 111–123, 1955; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9550.

An experimental method is described for investigating the bending deflection of compound, statically indeterminate beams. The method is founded on the analogy of the equations describing the deflection of the beam with the flow of an electric current in a circuit consisting of active resistances and transformers.

Electrical circuits are described, simulating a plain beam and a beam supported on an elastic foundation, for different conditions of constraint. A circuit is also described simulating a system of crossed beams working in conditions of equal deflections at the joints.

The electrical parameters of the elements of the circuit are stated. S. V. Boyarshinov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2763. Southwell, R. V., Use of an analogue to resolve Stokes's paradox, *Nature* **181,** 4618, 1257–1258 (Letters to the Editor), May 1958.

Stokes determined the slow flow about a sphere, but with the same "reasonable" assumptions failed to find a corresponding solution for a cylinder. Author considers this problem together with the analogous problem of the bending of a plate under edge loading and shows Stokes's assumptions to be impossible. In analogy, his assumptions place a torque on the plate at the hole (cylinder) but prohibit a balancing torque at the outer edge (∞). The solution to the problem is not attempted.

H. W. Emmons, USA

2764. Probine, M. C., An electrical analogue method of predicting the permeability of unsaturated porous materials, *Brit. J. Appl. Phys.* **9,** 4, 144–148, Apr. 1958.

The manner in which the permeability of unsaturated porous materials varies with moisture content has been investigated, using an electrical analog technique. The hydraulic resistance of a water channel in the porous material has been represented by an electrical transistor, and the three-dimensional network of channels by a corresponding three-dimensional resistance network. With all the resistors in circuit the electrical resistance across opposite faces of the network is assumed to be inversely proportional to the saturated permeability. Empty channels are not effective in transporting liquid so that drying of the material is simulated by progressively removing resistors representing the largest of the remaining water-filled channels. In this way the decreasing permeability of the material as it dries out can be related to its moisture content.

The predictions of the analog method agree very well with the experimentally determined values.

From author's summary by A. L. Simon, USA

2765. Luu, T.-S., Deviation of a main jet by an auxiliary jet slightly inclined in direction by the help of a rheoelectrical analogy (in French), *C. R. Acad. Sci. Paris* **246,** 1, 55–58, Jan. 1958.

The assumption of small deflections enables the problem to be treated by the method of small perturbations. The resulting potential flow equation is solved using an electrical analogy. The free boundaries are represented on one side by a straight conductor and on the other side by a series of plate electrodes equally spaced along a straight line and connected by equal resistances to a source of constant electric potential. The results are given as a set of curves connecting the deflection of the main jet and its contraction at infinity with position, angle and momentum of the auxiliary jet.

Little justification is given for various approximations involved in the analysis and in places a fuller explanation would have aided understanding. G. H. Lean, England

2766. Woodcock, A. H., Thwaites, H. L., and Breckenridge, J. R., An electrical analog for studying heat transfer in dynamic situations, ASME Ann. Meet., New York, N. Y., Nov.–Dec. 1958. Pap. 58-A-252, 9 pp.

An electrical analog has been constructed to represent the heat-transfer system between a clothed man and his environment. The primary purpose of this analog was to provide a visual indication of the manner in which skin temperature and heat loss through clothing are affected by varying wind, air temperature, activity, and clothing systems. The value of the electrical-analog approach in forcing the research worker to synthesize his concepts of heat transfer is discussed. An outline of methods, using electrical analogs, for investigating the significance of various environment, activity, and clothing factors is presented. Examples are given of the types of problems which can be solved rapidly with the instrument. The possibility of using analogs for planning experiments involving human subjects is discussed.

From authors' summary

2767. Greenspan, D., Note on analog techniques for resolving two-point boundary value problems, *Rev. Sci. Instrum.* **29,** 9, 787–788, Sept. 1958.

2768. Bryant, R. A. A., Use of the hydraulic analogy for "inside" problems, *J. Aero/Space Sci.* **25,** 8, p. 536 (Readers' Forum), Aug. 1958.

Kinematics, Rigid Dynamics and Oscillations

(See also Revs. 2834, 2968, 2971, 2972, 3107)

Book—2769. Meriam, J. L., Mechanics. Part I: Statics, 2nd ed., New York, John Wiley & Sons, Inc., 1959, xiv + 393 pp. $5.

Text is designed for basic course in Statics in normal engineering curriculums. Divisions of the material presented are (1) Principles of statics, (2) Force systems, (3) Equilibrium, (4) Structures, (5) Distributed forces, (6) Friction, and (7) Virtual work. Appendices to text include sections titled Vector methods, and Moments of inertia. Section on vector methods introduces dot and cross products and vector algebra, which could be used as alternatives to conventional mathematics of algebraic functions used exclusively by author in developing subject.

In author's "Preface to the instructor," he states his opinion that one of the aims of a course in statics should be "to develop an ability in problem formulation where connection between actuality and symbolic representation is required." This concept is carried through text which is profusely and clearly illustrated with examples of practical applications of statics to various engineering situations. Problems represent considerable range of difficulty and are presented in order of increasing skill required for solution. Answers to about two thirds of problems are given.

D. E. Hardenbergh, USA

Book—2770. MacMillan, W. D., Theoretical mechanics—statics and the dynamics of a particle, New York, Dover Publications, Inc., 1958, xviii + 430 pp. $2. (Paperbound)

Book—2771. Ames, J. S., and Murnaghan, F. D., Theoretical mechanics—an introduction to mathematical physics, New York, Dover Publications, Inc., 1958, ix + 462 pp. $2. (Paperbound)

Book—2772. MacMillan, W. D., Theoretical mechanics—the theory of the potential, 2nd ed., New York, Dover Publications, Inc., 1958, xiii + 469 pp. $2.25. (Paperbound)

An unabridged and unaltered republication of the first edition (1930). Ed.

2773. Krein, S. G., Mathematical questions relating to the theory of the motion of a solid body with cavities filled with liquid (in Russian), Trans. of the 3rd Mathem. Conference, Vol. I. Moscow, Akad. Nauk SSSR, 1956, p. 205; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10375.

Questions are examined of the existence of motion of a viscous incompressible liquid and of eddy motion of an ideal liquid with a set motion for the body and set initial conditions. The problems of both nonlinear and linearized types are investigated. The problems are studied of the existence of small vibrations of the liquid, of the completeness of the system of normal vibrations and of the characteristics of the frequency spectrum, in three cases: motion of an ideal liquid near the position of equilibrium in the presence of a free surface, motion of an ideal liquid near its point of rotation as a solid body, vibration of a viscous liquid in the vicinity of a fixed motion. In the last part of the paper an investigation is carried out of the joint vibrations of the solid body and the liquid in basically the same types of cases.

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2774. Moiseev, N. N., Problem of the motion of a solid body containing liquid masses, having a free surface (in Russian), Trans. of the 3rd Mathem. Conference, Vol. I, Moscow, Akad. Nauk SSSR, 1956, 206–207; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10376.

In its linear form the given problem merges with a system of integral-differential equations. Some special full orthonormalized system of specific functions is introduced. The system of integral differential equations leads to an infinite system of differential equations in some Gilbertian space H. This system proves to be a Lagrange system of equations with selected variables. The solvability (capacity for solution) in H of the obtained infinite system is indicated; also the discrete nature of the spectrum, and the asymptotic character of the specific values is examined. The analogy is established with the classical theorems of analytical mechanics: the theorems of Thomson and Lagrange. The development of the theory can be applied to the study of certain impact phenomena, to the evaluation of the dynamic characteristics of a ship containing a large quantity of liquid, and to a series of other questions. *Courtesy Referativnyi Zhurnal, USSR*
Translation, courtesy Ministry of Supply, England

2775. Ziemba, S., The influence of viscosity damping on the form of the trajectories of free vibration (in English), *Arch. Mech. Stōs.* **9**, 4, 487–504, 1957.

Topological analysis using phase trajectories is applied to a study of nonlinear damping characteristics. Trajectories are developed for the linear damping case demonstrating the patterns associated with varying degrees of viscous friction. Nature of the solutions is related to the role of the critical damping parameter. The analysis is then extended to nonlinear cases where the damping coefficient is assumed a function of the velocity. Author also demonstrates the use of a less conventional graphical construction which author claims to be more laborious but more illustrative of the influence of damping. Results show the character of the nonlinear vibration to depend on the position of the nonlinear damping characteristic relative to the characteristic of critical linear damping.

Reviewer believes author has clearly demonstrated the versatility of phase plane approach. R. B. Grant, USA

2776. Tumura, M., The stability of nonlinear vibrations in engineering. I (in English), *Tecbnol. Rep. Osaka Univ.* **8**, 47–53, Mar. 1958.

Author remarks that for practical uses a system is stable when the disturbances vanish rapidly. Therefore Lyapunov's definition of stability is weak, and he proposes for an isolated constant, periodic or almost periodic solution $\xi(t)$ of a system of differential equations, the following definition of stability. $\xi(t)$ is stable when for any t_0 there exists $\epsilon(>0)$ and when there exist $\lambda(>0)$ and k independent of t_0 and ϵ, such that any disturbance $\delta(t)$ of $\epsilon(t)$ satisfying the condition $\delta_0 \equiv |\delta(t_0)| < \epsilon$ fulfil the inequality: $|\delta(t)| \leqslant k\delta_0 e^{-\lambda(t-t_0)}$ for $t > t_0$. $\xi(t)$ is instable when it is not stable. Hence the necessary and sufficient condition for the stability is that all the real part of characteristic exponents of the variational equations are negative.

D. Graffi, Italy

2777. Zlamal, M, Stability of nonlinear forced vibration (in German), *Czech. Math. J.* **4(79)**, 1, 95–102, Mar. 1954.

The solutions of [1] $\ddot{x} + f(x)\dot{x} + g(x) = p(t)$, $p(t)$ periodic with period (T), important in dynamical problems, are considered. Author proves the following theorem using boundedness considerations:

I. Let $p(t)$ be periodic with period T

II. There exist constants $\omega > c > 0$ such that

$\phi(x) = f(x) - 2c \qquad \psi(x) = g(x) - \omega^2 x$ satisfy the inequalities

$|\phi(x)| \leqslant L_1 \qquad |\psi(x_2) - \psi(x_1)| \leqslant L_2 |x_2 - x_1|$

where $\omega L_1 + L_2 = L < c\sqrt{\omega^2 - c^2}$.

Then [1] above has a periodic solution of period T and all its other solutions converge to it exponentially.

In the simpler case $f(x) = 2c$ it is sufficient for the existence of a periodic solution of period T that for all $x_2 > x_1$

$$m(x_2 - x_1) \leqslant g(x_2) - g(x_1) \leqslant M(x_2 - x_1)$$

where $0 < m \leqslant M < 2c^2$.

Reviewer believes conditions to be restrictive but agrees with author that they are readily applicable.

L. Steg, USA

Book—2778. Malkin, I. G., Some problems in the theory of nonlinear vibrations (in Russian), Moscow, Gostekhteorizdat, 491 pp., illus., 1956, 16r.; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 9954.

The book is devoted to the exposition, with the assistance of the method of the small parameter, of the theory of the periodic or near-periodic vibrations of dynamic systems. Considerable space is assigned to the investigation of the stability of the vibrations. The stating of the problems is distinguished by their common plan of treatment while their solutions are outstanding by reason of their mathematical substantiation and uniformity. Much attention has been given to proofs of the existence of the solutions. In each section of the book practical methods of solution are recommended and the method of calculation is indicated. The method adopted for the exposition of the subject matter is to a large extent concentric, which makes the book accessible to a wide circle of readers. In Chapter I an investigation is made of the vibrations of quasi-linear systems with one degree of freedom (autonomous and nonautonomous) far away from resonance and with resonance present, and, in that category, resonance of the n^{th} order. An examination is carried out of the stability of the periodic motions obtained. As examples of practical methods of calculation mention is made of the resolution of the solution into a series by steps of

the small parameter μ in the case of the analytical function $F(t, x, \dot{x}, \mu)$, characterizing the nonlinearity of the system, and the method of successive approximations, when a nonanalytical characteristic of nonlinearity is present.

Chapter II is devoted to the finding of periodic vibrations of quasi-linear systems with many degrees of freedom. On the basis of the theory of the periodic solutions of nonuniform linear systems of equations with constant coefficients the singleness of the periodic solution (in the nonresonance case) of the nonlinear system is proved; this turns into the generating (in the solution of the linear system) when $\mu = 0$. In the case of resonance (when the fundamental equation of the generating system has roots of the form $\pm pi$, where p is a whole number or 0, or if the period of the exciting force is equal to 2π) deductions are made, without considering the existence of a periodic solution (which in this case depends on the family of arbitrary parameters), in the generating system, for conditions to include the presence of the periodic solution of the initial nonlinear system. From these last conditions a determination is made of the parameters of the generating solution. The practical issues arising from finding the solutions are examined: resolution by degrees of μ and the method of progressive approximations. A special case is scrutinized where the conditions being utilized for the determination of the parameters of the generating system are satisfied identically. The vibrations of autonomous systems in this chapter are studied by means of the same methods, taking into account the peculiarity of these systems, that is, the dependence of the solution on the arbitrary parameter (a constant, which can be added to the basic argument t) and the dependence of the period of vibrations on μ. Questions regarding the stability of the vibrations are considered in Chapter III. Explanations are given for the basic stability theorems, linked with the names of Lyapunov, Poincaré, Andronov and Witt; the fact is established of the existence of a determined form of solutions of linear equations with periodic coefficients; the problem is discussed of the reduction of linear equations with periodic coefficients to equations with constant coefficients; an examination is made of the peculiarities of the canonical systems; methods are shown for the approximate calculation of the characteristic indicators of systems dependent on the small parameter.

In Chapter IV the near-periodic vibrations of quasi-linear systems are looked into. Author sets himself limits by means of functions appearing as terminal generalized Fourier series. The methods given in this chapter are based on the investigations of N. M. Krylov and N. N. Bogolyubov. Aided by a conversion, analogous to the Krylov-Bogolyubov conversion for "standard" systems, and by going over to new variables (among which the arbitrary parameters of the generating solution will be found) conditions are expressed for the existence of a near-periodic solution in a quasi-linear nonautonomous system, for the general case of the presence of critical roots in the fundamental equation of the generating system. Practical methods are shown, curtailing the calculations, and criteria are established for the stability of the motions obtained. Further, methods are put forward which enable the near-periodic solution to be found in which, together with the frequencies contained in the excited functions $f_s(t)$ and $F_s(t, x_1, \ldots, x_n, \mu)$, frequencies also predominate closely akin to the frequencies of free vibrations of a linearized system. The methods described in the previous paragraphs only allow for the determination of a solution with excited frequencies. As examples the constrained vibrations were calculated for a regenerative receiver and for a gyroscopic car. In conclusion the known "principle of neutralization" is explained in general terms; this establishes the close tie between the standard and the simplified systems; the right-hand side of the latter appears as the averaged with time of the right-hand side of the standard system.

The fifth chapter is given up to the study of free and constrained vibrations of systems which can be described by equations with periodic coefficients. To start with, an examination is made to determine the zones of stability and instability (in relation to the value of parameter λ) for the equation

$$\frac{d^2x}{dt^2} + \lambda^2[1 + \mu f(t)]x = 0.$$

Then the problem is solved of the parametric resonance for mechanical systems, described by canonical equations, differing but little from equations with constant coefficients. The methods set out in the subsequent paragraphs of this chapter enable calculations to be made for the constrained periodic and near-periodic vibrations (resonance and nonresonance) of quasi-harmonic systems, dependent on the small parameter.

Systems akin to arbitrary linear ones are the subject of investigation in the sixth chapter. They are described by equations having the form of

$$\frac{dx_s}{dt} = X_s(t, x_1, \ldots, x_n) + \mu f_s(t, x_1, \ldots, x_n, \mu)$$

$$(s = 1, \ldots, n).$$

The importance of studying such equations is explained by the fact that in many cases the system, in principle, cannot be examined as linear and that, consequently, for the generating one, some kind of a nonlinear system has to be taken. It appeared that many of the results of examination of quasi-linear systems extend to these more general systems. The essential difference emanates from the fact that for the quasi-linear systems the equations in variations for the generating solution coincide with the uniform equations of the generating system, which does not occur in the systems discussed in the sixth chapter. The effective nature of the developed methods is illustrated by an example of the problem of the vibrations of a system with one step of freedom, close to the conservative system, a problem investigated in more detail in the posthumous work of A. M. Kats. In this chapter the solutions are also given of the problems on the periodic solutions of autonomous systems, akin to the arbitrary nonlinear, and the near-periodic solutions of the nonautonomous systems of that form.

The subject matter of Chapters VII and VIII consists of the theory of the Lyapunov systems and of systems in which the generating system appears to be the Lyapunov system; this subject matter has its counterpart, generally speaking, in chapters IV-VI of I. G. Malkin's "Lyapunov's and Poincaré's methods in the theory of nonlinear vibrations" (1949).

V. I. Osorin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2779. Basch, A., A constructive determination of eigenfrequencies of vibrations of a system with two degrees of freedom (in German), *Öst. Ing.-Arch.* **10**, 2/3, 119–124, 1956.

The eigenvalue problem for the natural frequencies and modes of an undamped vibratory system is equivalent to the problem of finding an affine transformation which simultaneously diagonalizes two quadratic forms: the kinetic and potential energies. This paper outlines a (complicated) graphical construction for obtaining the required transformation in the two-degree-of-freedom case where the quadratic forms are given as a pair of ellipses.

S. H. Crandall, USA

2780. Saydov, P. I., The influence of accelerations in pendulum systems (in Russian), *Izv. Leningrad Elektrotekhn. In-ta* no. 28, 47–55, 1955; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 8593.

By analysing the motion of a gyroscopic pendulum the point of suspension of which moves arbitrarily over the surface of the earth, author attempts a critical evaluation of the "Schuller principle" already known in the theory of gyroscopic phenomena.

While remaining within the limits of a linear theory, author endeavors, on the basis of analysis of the resulting equations, to

demonstrate the inconsistency of the Schuller principle in application to all pendulum systems.

Particular cases are examined of the motion of pendulum systems when the Schuller principle applies. [*See Prikl. Mat. Mekh.* **21**, no. 1, 1957]. M. E. Temchenko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2781. Kennard, E. H., A fresh test of the Epstein equations for cylinders, *J. Appl. Mech.* **25,** 4, 553–555, Dec. 1958.

Objections that have been raised against Epstein's equations of motion for uniform cylindrical shells and the author's extensions and conclusions from them are considered. A direct proof is offered that the equations must hold, and further reasons are given for believing that they can be used in practice, at least as a basis for obtaining rationally founded approximations.

From author's summary

Instrumentation and Automatic Control

(See also Revs. 2754, 2908, 2996, 3036, 3037, 3095)

Book—2782. Bellman, R. E., Glicksberg, I., and Gross, O. A., Some aspects of the mathematical theory of control processes, Santa Monica, Calif., The Rand Corporation, 1958, xix + 244 pp. (Paperbound).

The title of the book appears somewhat confusing as it is difficult to see how the theory of games, econometrics and similar matters can be brought within the scope of the mathematical theory of control processes.

The book investigates mainly certain variational problems appearing in all such questions in connection with optimizing certain functionals.

Part I outlines the fundamentals of such problems; in Parts II, III and IV this subject is elaborated in detail with numerous examples; Part V outlines the theory of games.

The reference to control systems appears in Chapter 3 where it is shown that the differential equations (d.e) of the uncontrolled process are of the autonomous type in terms of the dynamical variables x (second equation in 3.1) and that, owing to a forcing term of the form $f(t)$, the behavior of the system represented by the original d.e (of the uncontrolled process) can be altered (third equation ibidem) so as to force the system (its variables x) into some desired pattern. This is obviously the controlled process in terms of this text. As regards the control theory, this statement is not clear. In any control system the uncontrolled process is converted into "the desired pattern" (the controlled process) by means of a certain function of the instantaneous dynamical variables of this process; this means that any such control function (or operator) must necessarily be of the form: $f(x(t), x(t), \ldots x(t)dt, \ldots)$ and not merely $f(t)$. In fact, if it were simply $f(t)$, such a system would act without any relation whatever to the dynamics of the system to be controlled so that the dynamics of the system in such a case would not be a determining factor for the control. This seems to be the point of a fundamental difficulty unless by $f(t)$ authors mean something else than a simple implicit dependence on t.

Leaving out this point, the rest of the paper presents a thorough outline of the variational methods subject to constraints and relates to problems of optimizing certain functionals; here the questions are treated in a very general manner, and are of a considerable interest, particularly in view of numerous examples.

As regards the econometrics, games, etc., one may question whether they also enter into the general scope of the control theory. The text does not give any indication in this connection inasmuch as the interest of authors seems to be centered on problems of optimizing certain functionals.

In fact, if all this subject is to be included also in the scope of the control theory, it must possess at least its fundamental feature of a closed loop of cause-effect relationships. In fact, a physical system may not have any optimizing features; but if it has a "closed loop" structure by which the output signal counteracts the input signal, it is certainly a control system in the usually accepted sense of this word.

Thus, for instance an economic problem (say, on national scale) may be regarded as an "uncontrolled system" (e.g. possibility of slumps, etc.). If one wishes to consider it from the standpoint of the control theory, one has to "close the loop" by adding the effect of the Government regulations counteracting the effect of the slump; the action of the Government in this case may be regarded as a kind of a feedback reducing the "error function" which ultimately controls the economic process. The optimizing effect in this case finds its expression in the skill and competence with which the Government takes its measures. On the formal basis, this would be a control system if one could put into equation many things which are difficult to express mathematically, at least those pertaining to human nature (of individuals as well as of the mass behavior). No such extensions, however, are indicated in this report and the comparison of different situations is carried out along the question of optimizing certain features without attempting to extend this comparison to these systems as a whole.

The report merits considerable attention on the part of those who are interested primarily in the underlying philosophy of these questions rather than in the engineering details of the control theory. N. Minorsky, France

2783. Petrov, V. V., and Rutkovskii, V. Yu., Theory of simple delay-relay servomechanisms (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 4, 16–32, Apr. 1956.

In this paper the theory of relay systems with dead time and relay dead zones is developed. High-order systems are approximated by low order to simplify the theory. Authors employ a surface with parallel phase planes connected together, analogous to a Riemann surface. The theory is first developed for the case where there is no relay dead zone, and then with such a zone included. Solution trajectories are obtained on the multiple-phase plane surface. R. Oldenburger, USA

2784. Kalman, R. E., and Koepcke, R. W., Optimal synthesis of linear sampling control systems using generalized performance indexes, ASME-IRD Conf., Newark, Del., Apr. 1958. Pap. 58-IRD-6, 7 pp.

Paper deals with design of linear control systems so as to minimize some quadratic performance index. Method of design is applicable to both sampling and continuous control systems. Using concepts of "state" and "transition matrix"which have been developed in earlier papers by the first of the two authors, design problem can be solved, via technique of dynamic programming, by means of simple iterative computations. In this way, the classical Wiener method of design is extended in several different directions:

(a) Using generalized performance indexes;

(b) Optimizing for classes of input signals rather than single inputs;

(c) Assuring stability of the optimally designed system.

Concrete example is considered and results discussed. Appendix contains outline of technique of dynamic programming used for solution of problem considered in paper.

From authors' summary by Agnes H. Zaludova, Czechoslovakia

Book—2785. Conway, H. G., edited by, Aircraft hydraulics. Vol. II, Component design, New York, Macmillan Co., 1957, ix + 198 pp. $9.

"Component fundamentals" as outlined in this volume is excellent information for the student or designer faced with the problem of evaluating hydraulic equipment in aircraft systems. These fundamentals are the stepping stones used to further design and develop components for today's high-performance aircraft.

With the greatly increased speeds of aircraft, missiles and rockets, resulting in higher pressures and temperatures of systems, it is necessary to have a comprehensive knowledge of component functions in order to develop these parts so that they can function properly in these environments. While this volume does not cover the most recent developments relative to effect of pressure and temperatures, it does cover very well the basic function of such components.

Fast-changing requirements in present hydraulic systems make it necessary that the student or designer have the most up-to-date information possible. Future revised editions, covering the results of the latest developments and practices, will keep up-to-date the value of this book, which is a welcome addition to the small amount of published material available on this subject.

A. P. Gordon, USA

2786. Pavlik, E., Pneumatic universal controllers with progressive speed of adjustment (in German), *Regelungstech.* **6,** 4, 128–134, 1958.

Pneumatic controllers with progressive speed of adjustment, which speed varies directly with the value of the deviation, prove particularly suitable for problems of process control. Satisfactory results will be achieved by their use even for controlled plants having a high disturbance level. Owing to the self-stabilizing properties of the progressive controllers, their adaptation to individual plants is less critical than with ideal PID-controllers. The working principle of these controllers is described and compared with devices as supplied by the manufacturers.

From author's summary

2787. Shengeliya, P. G., Utilization of pressures in hydroelectric stations during controls of short duration (in Russian), *Tr. In-ta Energ. Akad. Nauk GruzSSR* **10,** 3–18, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10355.

2788. Lifson, M. W., Some effects of wind and temperature gradients on the design of missile flight control systems, *Aero/Space Engng.* **17,** 9, 49–52, Sept. 1958.

2789. Mundo, C. J., and Tooher, E. W., Guidance for the space age, *Aero/Space Engng.* **17,** 9, 30–33, Sept. 1958.

2790. Hodge, E. D., and Davis, S., Applying electromechanical servo actuators, *Control Engng.* **5,** 5, 96–101, May 1958.

Elasticity

(See also Revs. 2763, 2773, 2812, 2819, 2821, 2825, 2833, 2900, 2909, 2959)

2791. Rogozinski, Marian, On the possibility of better utilization of the analogy between stress and strain in the theory of elasticity (in English), *Arch. Mech. Stōs.* **9,** 6, 713–730, 1957.

Author discusses stresses satisfying equations of linear elasticity for isotropic materials which are expressible as the symmetric part of the gradient of a vector. Illustrative examples are given. With some noted exceptions, the stresses must be harmonic functions and the mean normal stress must be a linear function of Cartesian coordinates.

J. L. Ericksen, USA

2792. Varvak, P. M., A solution of the three-dimensional problem of the theory of elasticity (in Russian), Researches on problems of stability and strength, Kiev, Akad. Nauk USSR, 1956, 93–101; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9257.

The expressions in the solutions of B. G. Galerkin [Coll. Works, vol. I, Moscow, 1952] are applied to problems which it is possible to restrict to a single biharmonic function. By replacing the biharmonic equation with its form in finite differences, author obtains a system of linear equations for determining the unknown functions in the joint-nodes of the lattice. The expressions for the displacements and stresses are likewise reduced to the values of the required function in the joints of the lattice.

I. S. Arzhanykh

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2793. Smolovik, I. I., The solution of problems in the three-dimensional theory of elasticity by means of three Maxwell stress functions (in Russian), Trudī Nauch. Konferentsii Stalinskogo Ped. In-ta no. 1, Kemerovsk., Kn. Izd-vo, 1956, 296–301; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9258.

The equations of statics and the Beltrami relationships are satisfied if the stresses are expressed by three biharmonic Maxwell stress functions. Author has failed to notice, however, that functions introduced in this manner are not independent; consequently, paragraphs 2 and 3 of the paper are erroneous. For instance, comparison of Eq. (2, 3) with the expression (1, 6) leads to the conclusion that the displacements in the three-dimensional theory of elasticity are independent of Poisson's ratio.

A. I. Lur'e

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2794. Nowacki, W., A plane distortion problem (in English), *Arch. Mech. Stōs.* **9,** 4, 417–438, 1957.

Author deduces integral expressions for the Airy stress function and for the corresponding state of displacement and stress in a thin, simply-connected plate with traction-free edges due to a distribution of initial strain over a portion of it. He evaluates the integrals in closed form for the case of nuclei of strain in an infinite plate, a semi-infinite plate, and a strip.

H. Deresiewicz, USA

2795. Theodorides, P. J., Structural analysis of high-speed wings for a quasi-triaxial elastic state in the skin, bi-axial in the longitudinals (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6,** 71–85.

Under a normal load only and using small-deflection theory and neglecting stress normal to wing thickness, author derives expressions for the remaining five stresses in terms of the mean deflection of the mid-plane. The expressions include correcting terms to the usual two-dimensional stresses. A somewhat involved fourth-order partial differential equation is given for the mean deflection, but no solutions are given.

B. E. Gatewood, USA

2796. Chatterjee, B. B., Stresses in an aeolotropic elliptical disc rotating about an axis of symmetry lying in its middle plane, *J. Technol.* **2,** 2, 137–139, Dec. 1957.

Thin, aeolotropic, elliptical disk rotates about its minor axis. Assuming plane stress, solution is given of equations of elasticity. Aeolotropic wooden disk provides an application.

M. C. Steele, USA

2797. Obodovsky, B. A., The strength calculation of a circular, rotating disk, weakened by a circular aperture (in Russian), *Sb. Naucb. Trudī Zhdanovsk. Metallurg. In-ta* no. 3, 293–299, 1955; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9294.

The problem is examined of the stress condition in a thin, homogeneous, circular disk, weakened by an eccentric aperture and

uniformly rotating about an axis passing through the center of the disk and perpendicular to the plane thereof.

The solution uses the method of D. I. Sherman [*Dokladi Akad. Nauk SSSR* **39,** 9, 911–913, 1940] for doubly-linked regions, founded on the analytical extension of the functions of the Kolossov-Muskhelishvili variable, through one of the boundaries of the region, by means of an auxiliary function, for which the integral equation is given. The latter is solved approximately by reducing to an abbreviated system of linear, algebraic equations.

I. A. Prusov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2798. Kartashov, V. A., Some cases in the plane stress problem of the theory of elasticity (in Russian), *Trudi Saratovsk. Avtomob-dor In-ta sb.* 14, 108–114, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8151.

Formulas are given for the plane stress problem of the theory of elasticity. The possibility is indicated of utilizing existing solutions in rectangular coordinates (when there is a linear dependence of the tangential stress on the coordinate) to obtain corresponding expressions in oblique-angled coordinates.

V. K. Prokopov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2799. Boym, A. A., The stress concentration in a stretched infinite plate weakened by a trapezoidal cutout (in Russian), *Nauch. Zap. Lvovsk. Politekhn. In-ta* no. 29, 121–125, 1955; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7006.

The stress condition is determined in a stretched, infinite, isotropic plate with an aperture in the form of an isosceles trapezium, for two particular cases: (1) cutout is unsupported and unloaded; (2) cutout is reinforced by a rigid ring.

A numerical example is investigated, for which stress curves are given of the distribution along the outline of the cutout.

I. A. Prusov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2800. Boym, A. A., The stress concentration in a stretched, infinite plate weakened by an elliptical cutout, the edge of which is reinforced by a welded elastic ring (in Russian), *Nauch. Zap. Lvovsk. Politekhn. In-ta* no. 29, 126–132, 1955; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7007.

The method of N. I. Muskhelishvili cited in the work of M. P. Sheremetyev [*Uch. Zap. Lvovsk. Gos. Un-Ta, Ser. Fiz.-Mat. Nauk* **12,** no. 3, 1949] is applied to the solution of the stress condition in a stretched, isotropic, infinite plate with a reinforced cutout, the outline of which is conformally represented on a unit circle by means of a rational function. In the work in question the cutout is assumed to be elliptical.

I. A. Prusov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2801. Basilievitch, V., The bending of an I-beam of variable section (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6,** 198–208.

Paper discusses stress distribution in I-beam with cutaway upper flange over part of its length. Introducing Fourier series for tangential stresses along connections of web to lower flange and remaining part of upper flange, introducing concentrated tangential forces between web and upper flange at the ends of this flange, and equating axial strains along lines of attachment of flanges to web results in infinite system of equations for Fourier coefficients. Numerical results are given for uniformly loaded beam on simple supports (flange width 2, web height 4, beam length 40, length of remaining upper flange in midportion 20). Reviewer notes that solution is approximate since the boundary condition of zero shear stress along (transverse) ends of upper flange is ignored.

W. T. Koiter, Holland

2802. Kozhevnikova, V. N., Stress distribution near a rectangular orifice in a ponderable body (in Russian), *Zap. Leningr. Gorn. In-ta* **33,** 3, 99–108, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4576.

An examination of the two-dimensional problem for a large plate weakened by a small curvilinear orifice, almost rectangular, the ratio of the sides being 1 : 2. The problem is solved by N. I. Muskhelishvili's method, and in comparing the tables author used the well-known solutions from this paper. Three cases of loading are analyzed: (1) Homogeneous compression in one direction; (2) action of the actual weight; (3) hydrostatic pressure on the faces of the orifice. There is no mention of the fact that the polar coordinate θ in the tables refers to a unit circle on which the region is reflected, and there is no indication of what radii the tables are made up for.

P. M. Varvak

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2803. Meriam, J. L., Lyman, P. T., Steidel, R. F., and Brown, G. W., Thermal stresses in the SS Boulder Victory, *J. Ship Res.* **2,** 2, 55–71, Oct. 1958.

The lack of comprehensive experimental measurements of thermal stresses induced in a ship's hull structure by diurnal temperature changes prompted the present study. Its essential purpose is to provide reliable prototype measurements of thermal stress patterns around a complete transverse section. These results are compared with stresses computed by the theory of simple beams under arbitrary temperature distributions across their section. The research was conducted under direct sponsorship of The Society of Naval Architects and Marine Engineers at the Maritime Reserve Shipyard in Richmond, Cal. The SS *Boulder Victory* was supplied as the test vessel by the Maritime Administration. The ship was instrumented during June and July, 1957, and tests run during August. Various temperature conditions were observed and corresponding strain measurements taken. The results are consistent and give a reliable picture of thermal-stress conditions in the ship. They also verify the prediction of thermal stresses afforded by the simple beam theory.

From authors' summary

2804. Ignaczak, J., The stresses due to a nucleus of thermoelastic strain in a semi-infinite plate containing a semicircular notch (in English), *Arch. Mech. Stös.* **10,** 5, 707–713, 1958.

A semi-infinite plate with a semicircular notch on the edge is kept at zero temperature, except for a nucleus of thermoelastic strain located at a point with the temperature equal to unity. The stress function of this problem is assumed in form of an infinite series built up of two special sets of biharmonic functions. The boundary conditions at the edge of the notch are satisfied by the method of Maunsell which gives an infinite system of linear equations for the unknown coefficients of the above series. Approximate solution is not difficult.

The problem belongs to the category of advanced questions of thermoelasticity. Both its character and the results are in full agreement with the ever-growing standard of applied mathematics in Poland.

V. Vodicka, Czechoslovakia

2805. Seth, B. R., Finite thermal strain in spheres and circular cylinders (in English), *Arch. Mech. Stös.* **9,** 6, 633–646, 1957.

Author considers steady-state thermal stresses, assuming that the classical equation $\nabla^2 T = 0$ for temperature T still holds even when deformation is large. A special linear stress-strain law is assumed using finite strain referred to the strained state. Stress also depends on a power series in T. Stresses are evaluated in

spherical shell or long thick-walled cylinder when temperature has given constant values on both surfaces which are otherwise stress free. Paper contains no discussion of thermodynamics for large deformations nor of validity of approximate equations used.

A. E. Green, England

2806. Panasyuk, V. B., Podstrigatch, Ya. S., and Yarema, S. Ya., Temperature stresses in the drum walls of high-pressure steam boilers (in Russian), *Nauk. Zap. In-ta Machinoved. i Avtomatiki, Akad. Nauk USSR* **5,** 5–24, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9292.

The periodical stoppages during the working of drums of high-pressure steam boilers expose these to irregular heating, as a result of which thermal stresses are set up in the drum walls.

The present paper gives theoretical and experimental results on the action of thermal stresses in the walls of a freely-supported, cylindrical drum; it is assumed that the temperature varies only over the contour of the cross section, according to a law: $t = t(s)$ (s = arc), and remains constant along the generating line as well as through the thickness of the wall. A numerical example of the calculation of the temperature stresses is given. An experiment is described on the determination of the temperature field in the wall of the drum, as well as the determination of the elastic deformations. These elastic deformations have been measured by means of wire-resistance gages connected in a bridge circuit. The calculated data are compared with the experimental results.

V. I. Danilovskaya

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

2807. Keintzel, E., Analysis of temperature stresses in ring-shaped girders supporting tanks with warm liquids (in Roumanian), *Rev. Constr. Mat. Constr.* **10,** 1, 25–28, 1958.

Structural analysis of circular girders with constant and variable cross section, to be used also for concrete bins. Author refers to S. Waldemar, M. Hangan, Biezeno and Grammel.

J. J. Polivka, USA

2808. Barta, J., The estimation of tension in torsion (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6,** 112–119.

Paper gives upper and lower bounds for local stress in torsion of prismatic bars. Example shows that sufficiently close bounds may be obtained with comparatively little effort.

W. T. Koiter, Holland

2809. Netrebko, V. P., The constrained torsion of an elastic parallelepiped (in Russian), *Vestn. Mosk. In-ta* no. 6, 11–26, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9297.

Two cases are examined of a compound problem of the theory of elasticity for the case of a rectangular parallelipiped. Using the Castigliano method of variations, author obtains an approximate solution for the case of the torsion of a parallelipiped, on the condition of complete constraint of one or both of its bases, to which torsional moments are applied. In the construction of the variational stress tensor, author uses the Mohrer stress function and the Prandtl function; the boundary conditions are fulfilled rigorously (without alleviation), while the conditions of compatibility of the deformations are only fulfilled approximately, with the help of Castigliano's variational equation. In addition to the fundamental shearing stresses, in torsion, the remaining components of the stress tensor are likewise not equal to zero. In the vicinity of the constrained bases, longitudinal normal stresses are also perceptible. Two numerical examples are analyzed.

M. M. Filonenko-Borodich

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

Viscoelasticity

(See also Rev. 2852)

2810. Bychawski, Z., Resolving kernel of the Volterra equation in the case of the generalized creep function (in English), *Arch. Mech. Stos.* **9,** 2, 247–257, 1957.

The stress problem in a structure subject to creep can be written in the form of a Volterra integral equation. Assuming for the creep function a finite sum of exponentials the kernel of the equation becomes separable. Author presents differential equation for resolving kernel and shows application to simple prestressed-concrete structure.

H. Parkus, Austria

2811. Grubin, A. N., Plane transverse bending of rods of constant section in conditions of steady creep (in Russian), *Sb. Naucb. Tr. Kuibyshevsk. Industr. In-ta* no. 6, part 2, 3–22, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10892.

A method is proposed for the solution of problems on the transverse bending of beams of constant section in conditions of steady creep, described by the formula $H = BT^m$, where T and H are the intensities of the tangential stresses and velocity of deformation of shear, respectively, B and m are constants. In solving a problem of this nature use is made of the variational principle, which can be described for the case being investigated by the equation

$$\delta \int_l \int_h \left(\frac{\sigma_x^2 + \sigma_y^2}{2} + r_{xy}^2 \right) dx\, dy = 0 \qquad [*]$$

where h is the height and l is the length of the beam.

The idea contained in the method is as follows: (1) an infinite number of functions is found for σ_x, σ_y and r_{xy}, depending on one parameter k and satisfying the equations of equilibrium and boundary conditions; (2) a minimum of integrals is found for equation (1) by means of differentiation along parameter k, the derivatives obtained being equated to = 0, and by the determination of the corresponding values for k; and (3) the values of k determined in this way are substituted for the earleir found functions for σ_x, σ_y and r_{xy}. For the components of σ_x a function is selected

$$\sigma_x = \frac{M_x}{I_k} \eta^k, \; I_k = 2b \int_0^{h/2} \eta^{k+1} d\eta = \frac{bh}{2+k} \left(\frac{h}{2} \right)^{1+k}$$

where M_x is the bending moment, I_k the so called "generalized moment of inertia." The proposed method for solving the problem set is illustrated by two examples of deflection of girders, rigidly fastened at one end. In one case a force is acting on the girder, which is concentrated at its free end; in the other, the load is evenly distributed.

N. I. Malinin

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

2812. Arutyunian, N. Kh., and Chobanian, K. S., Considering creep in calculating the torsion of prismatic bars composed of various materials (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 6, 16–34, June 1956.

Problem considered is torsion of a prismatic rod which consists of several separate prismatic rods soldered together on their side surfaces. The materials are assumed to obey the creep law

$$\gamma_{xz}^{(i)} = \frac{\overset{(i)}{rxy}}{Gi} - \int_{\tau_1}^{t} \overset{(i)}{rxz}\,(\tau) \frac{\partial}{\partial \tau} \omega_i (t, \tau)\, d\tau$$

where $\omega_i (t, \tau)$ is the creep strain under pure shear, t is time, G the shear modulus, γ the shear strain, and τ does double duty as both a shear stress and a dummy variable. General solutions are obtained for the stress function in each of the bars. Specific so-

lutions are given for a general cross section with a thin covering layer, a circular cross section with reinforcing core, a circular cross section with reinforcing cover, and rectangular cross sections.

I. Finnie, USA

2813. Feughelman, M., Mechanical properties of wool fibers, I. Creep in the "Hookean" region of wool fibers in water, *J. Text. Inst. Trans.* **49,** 8, 361–378, Aug. 1958.

Author reports creep results on wool fibers in which the stress was applied to the fibers held under water at various temperatures. All measurements were carried out in Hookean region, i.e. strain not exceeding 1%. The instantaneous strain recorded was all strain occurring up to time of about 1 second after application of load, and creep was measured for times up to 2×10^3 seconds. Fifty fibers chosen from a uniform stock of specially selected sheep were measured. It was found that a three-constant formula for the strain s for a given load f is of the form

$$s = f_0 [C_0 \log(t/t') + d_0]$$

Results are discussed with reference to model consisting of distribution of Burte-Halsey two-state units [*Text. Res. J.* **17,** p. 465, 1947] which is shown to give correct form of strain relation. The model chosen gives Young's modulus varying as log (rate of loading) for constant rate of loading experiment. This agrees with previous work. Rate of variation with temperature of instantaneous strain predicted from model agrees with experimental values.

K. W. Hillier, England

2814. Rigby, B. J., Mechanical properties of wool fibers, II. Single fibers at 0% r.h. in the yield region, *J. Text. Inst. Trans.* **49,** 8, 379–383, Aug. 1958.

Tensile properties of wool fibers kept in anhydrous glycerol to maintain humidity of 0% R.H. are reported. Load/extension, creep under constant load, and stress relaxation at constant strain have been measured. Only short-time measurements were made (1 minute). Results show that behavior of dry wool is unlike that of wet wool fibers; no clearly defined Hookean region exists in the dry state and Young's modulus measured as slope of load/extension move at 1% strain is independent of temperature over range 10–80 C and also independent of rate of straining 0.75–250%/minute. Brief discussion of results in terms of molecular forces is given.

K. W. Hillier, England

2815. Karapetyan, K. S., Influence of the test sample dimensions on the settling and creep of concrete (in Russian), *Izv. Akad. Nauk. ArmSSR, Fiz.-Matem. Estestv. i. Tekhn. Nauk.* **9,** 1, 87–100, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8500.

The results of the author's tests are given for the determination of shrinkage and creep in slightly stressed concrete samples cylindrical in shape and of different diameters. Part of the samples were given a coating of bitumen and wrapped in waxed paper to prevent loss of moisture in the samples. Lithoidal pumice stone was used as aggregate. The tests showed that in the first period of hardening of the samples containing the lithoidal pumice it is not the shrinkage that takes place first but swelling and that the shrinkage of the insulated (bitumen wrapped) samples was several times smaller than the shrinkage of un-insulated samples. It was also established that deformation due to shrinkage in samples of small diameter develops more intensively than in samples of large diameter. The limit of deformation due to shrinkage in a period of 600 days was 0.7 mm/m for uninsulated samples with a diameter of 14 cm and 0.61 mm/m for uninsulated samples with a diameter of 25 cm, and for insulated samples of 14 cm diameter 0.23mm/m. The creep of concrete in uninsulated samples decreased with increase in the dimensions of the samples, which the author attributes to water evaporation. A deduction is made that creep in concrete is due to the viscosity of the gel constituent of the cement stone and of capillary phenomena. The creep of concrete when compressed, conditioned by capillary phenomena, is several times greater than the creep conditioned by the gel viscosity of the cement stone. The dimensions of the samples have an appreciable influence on creep deformation: the larger the sample, the smaller is the creep.

A. E. Desov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2816. Mellgren, A., Measuring accuracy in creep tests. I. Influence of eccentricity of load (in English), Instn. Hallfasthetslara, Kungl. Tekn. Hogskolan, Stockholm, Publication no. 125, 19 pp., 1958.

If creep specimens are subjected to an eccentric load, the creep rate for secondary creep will be in error. Author has presented an approximate solution for determining this error. A comparison of his solution with exact solutions which are available for a few cross sections indicates that his approximate solution gives good results as long as the nonuniformity in the strain rate across the specimen is small. He has considered the effect of nonuniformity due to eccentric tension or compression loads, due to nonhomogeneous material, and due to asymmetric temperature distribution. The error in the strain rate is greater if the nonuniformity in the strain rate across the specimen is caused by nonhomogeneous material than if it is caused by an eccentric load.

O. M. Sidebottom, USA

Plasticity

(See also Revs. 2848, 2851, 2856, 2859, 2876, 2889, 2912, 2919, 2923, 2929, 2932, 2933, 2934, 2950)

2817. Olszak, W., and Perzyna, P., Extremum theorems in the theory of plasticity of nonhomogeneous and anisotropic bodies (in English), *Arch. Mech. Stōs.* **9,** 6, 695–712, 1957.

An elastic-plastic material is considered with a yield function Ψ which may be initially anisotropic, and may depend explicitly upon the space coordinates. Isotropic strain-hardening is assumed; hence, if $\Psi = \Psi_0$ is the condition for initial yield, the current yield condition is always of the form $\Psi = \text{const}$. The yield function is taken as the plastic potential for the flow law.

Extremum principles for a homogeneous, initially isotropic material under the above postulates were proved by Hodge and Prager in 1948 [AMR **2** (1949), Rev. 1387]. Present paper proves the same principles for more general title material.

P. G. Hodge, Jr., USA

2818. Berezantsev, V. G., Methods of solving axially symmetrical problems in the theory of plasticity (in Russian), *Sb. Leningr. In-ta Inzh. Zh.-d. Transp.* no. 150, 25–38, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10849.

The axially symmetrical problem in the theory of plasticity is investigated. The author, following Heinke, utilizes the approximate method, which is founded on the circumstance that the network of lines of slip in the axially symmetrical problem is adopted in the form in which it is also found in the corresponding plane problem: (1) The problem of impressing of a cylindrical die in an infinite semi-space. (2) The problem of impressing on a cylindrical supporting wall, if an even distribution of pressure is acting on the surface. (3) The problem of plastic equilibrium when, on the surface bounding the semi-infinite space, a load is operating outside a circle of a certain radius.

A. N. Kochetkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2819. Lopatin, B. V., Elastic-plastic eccentric tension (in Russian), *Sb. Nauch. Tr. Ivanovsk. Energ. In-ta* no. 7, 22–34, 1957; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10866.

An investigation is made of the eccentric tension in the principal plane of a rod of rectangular transverse section. The material of the rod is assumed to be ideally elastic-plastic. Relations are brought in to determine the position of the neutral axis and the values of the active stresses when under elastic and elastic-plastic deformation. Differential equations are deduced for the bent axis of the eccentrically tensed rod in the elastic and plastic zones and expressions are given for the determination of its maximum deflection at different values for the tensional forces, eccentricity and dimensions of the rod.

Yu. A. Rokovshchik

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2820. Tarassenko, I. I., and Tarassenko, E. N., Plasticity and strength criteria for metals (in Russian), *Zap. Leningrad. Gorn. In-ta* **33**, 3, 109–116, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9408.

Two plasticity criteria are investigated:

(1) The maximum tangent (shear) stress is a function of the mean hydrostatic stress;

(2) The octahedral stress is a linear function of the mean hydrostatic stress.

To find the linear function in either case it is sufficient to know the yield point in tension and compression, after which the yield point in torsion can be calculated. Evaluation of the results obtained by the present, as well as other, authors, shows that the first condition is well satisfied by the experimental results, while the second gives excessive values for the yield limit in torsion.

V. A. Lomakin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2821. Moskvitin, V. V., The repeated elastoplastic torsion of bars (in Russian), *Vestn. Mosk. In-ta* no. 1, 31–40, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9421.

The stress and strain conditions in torsionally loaded, prismatic bars are examined on the assumption that, before application of the load, the bar possesses particular residual stresses and strains, retained after elastoplastic torsion. It is demonstrated that the problem of analysis of repeated torsion of a bar can be reduced to algebraic forms if the problem of the elastoplastic torsion of the particular bar has been solved for the first loading case. It is assumed that the material has a creep cross section. An example is given.

A. M. Kochetkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2822. Val'ter, L. L., Graphic method of determining the loading limit for a steel bar during the joint action of a bending moment and a longitudinal force (in Russian), *Trudi Leningr. Korablestroit. In-ta* **16**, 56–59, 1955; *Ref. Zh. Mekh.* no. 4, 1957; Rev. 4737.

2823. Trofimovich, V. V., The work of steel struts in an elastic-plastic state when loaded with immovable and movable loads (in Russian), *Sb. Trudi In-ta Stroit. Mekhan. Akad. Nauk USSR* no. 21, 27–43, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5950.

2824. Shield, R. T., and Ziegler, H., On Prager's work-hardening rule (in English), *ZAMP* **9a**, 3, 260–276, Sept. 1958.

Paper discusses in mathematical terms Prager's work-hardening rule [*Proc. Inst. Mech. Engrs.* **169**, p. 41, 1955] and analyzes its implications for some selected stress conditions commonly met in practice, e.g. plane strain, plane stress, combined tension and torsion, etc. This rule assumes that the yield surface (the yield condition is normally represented as a surface in stress space) is rigid but undergoes a translation in the strain increment direction and its main advantage is that, for certain yield conditions, mathematical analysis is simplified. In most of the cases considered the rule is seen to apply, but in certain others the yield surface deforms during hardening. These latter coincide, in the examples considered, in those cases where (a) more than one normal stress is different from zero and (b) the material obeys Tresca's yield condition..

P. W. Whitton, England

2825. Worley, W. J., Inelastic behavior of aluminum alloy I-beam with web cutouts, *Univ. Ill. Engng. Exp. Sta. Bull.* 448, 35 pp., Apr. 1958.

Report attempts to answer the question, "What shape web-section cutout results in the least reduction in fully-plastic load-carrying capacity per pound of beam weight?" The process used in arriving at a partial solution is outlined.

Data are presented on the elastic and fully-plastic behavior of 6061-T6 aluminum alloy I-beams with various cutout configurations. A sufficiently large number of tests were conducted using I-beams with rectangular- and elliptical-shape web-section cutouts to establish the validity of the mechanism method of analysis. The Upper Bound Theorem was used to predict the fully-plastic loads. These tests included both pure bending and center loading with various cutout lengths and spacings. The results indicated that for a pure bending load there was little difference between the fully-plastic strength of I-beams with rectangular cutouts and with elliptical cutouts. For center loading, the elliptical cutouts were much stronger.

The tests permitted the formulation of the failure mechanism in mathematical form suitable for programming on the ILLIAC digital computer. A series of cutout shapes were then investigated for a particular center-loaded I-beam of fixed length with one cutout in each half span. The equation defining the cutout is expressed as

$$\left(\frac{\pm u}{a}\right)^{\alpha} + \left(\frac{\pm v}{b}\right)^{\beta} = 1$$

where u and v are the coordinates of the elliptic-type curves, a and b represent the major and minor axes, and α and β are the variable exponents which determine the shape of the cutout.

The ILLIAC results predicted that $\alpha = \beta = 1$, or a diamond-shape cutout, would yield the greatest load-carrying capacity per pound of beam weight. This result was verified by experiment for both 3-in. and 6-in. depth 6061-T6 aluminum alloy I-beams.

From author's summary

2826. Fleischer, R. L., Single crystal lattice rotation during compression, *J. Mech. Phys. Solids* **6**, 4, 301–306, July 1958.

Author shows experimentally that the Taylor rotation under easy glide during compression of single crystals is not of general application. The Taylor rotation occurs when the normal to the slip plane rotates toward the axis of compression. This type of rotation is not the reverse of lattice rotations found in tension. By defining the compression axis as the axis parallel to the specimen sides, the reverse of the tension rotation is found in compression. On this basis, author predicts that in many of the common cases of compression the specimen axis will rotate away from the slip direction. In cyclic bending or push-pull tests no net rotation from average lattice orientation should occur.

Experimental evidence of lattice rotations using Laue back-reflection x-ray techniques is presented for high-purity crystals of aluminum and copper deformed in compression, bending and fatigue. Compression of an aluminum crystal shows that near the compression plates the Taylor rotation occurs. At the center of the specimen the slip direction moves away from the compression axis and is the opposite of that found in tension. The end effects extend into the sample a distance equal to the thickness. A similar effect

as in center of compression specimens is found on compression side after plastic bending. In fatigue no lattice rotation was found, indicating that the rotations in tension and compression are equal and reversed. F. Garofalo, USA

2827. Fleischer, R. L., and Chalmers, B., Grip effects in the deformation of single crystals, *J. Mech. Phys. Solids* **6,** 4, 307–313, July 1958.

Authors point out that work-hardening properties of single crystals are affected by the external dimensions of the specimen, and suggest that the effect is due to bending moments applied by the grips. A model is proposed for calculating the shear stresses from the reaction of the grips as the thickness of the specimen is varied. The model is applicable to plastic flow in general but is aimed primarily to slip in face-centered cubic materials. It is assumed that slip is predominant in one slip system subjected to the highest resolved shear stress. Hardening is caused by slip on other systems which are operative even during easy glide and lead to a positive slope in the flow curve during this stage. When the resolved shear stress is sufficiently high on intersecting slip planes, appreciable flow on secondary systems terminates easy glide. The grip stresses are important since they alter the stresses on the various slip systems and therefore affect easy glide characteristics and the inception of appreciable cross slip.

Authors predict that as the specimen thickness is increased, (1) the yield strength is unaffected, (2) the rate of work-hardening should increase appreciably, (3) the resolved critical shear stress for flow in a secondary system should decrease, (4) strain at the end of easy glide should decrease, and (5) the rate of change of slope of the flow curve should increase. Qualitative agreement with experimental results is shown. The nature of the effect of length on flow properties is also discussed.

F. Garofalo, USA

2828. Payne, H., Czyzak, S. J., Greiner, J. H., and Lin, T. H., A modification of Taylor's method for calculating the plastic stress-strain relation in face-centered cubic crystals, *J. Mech. Phys. Solids* **6,** 4, 314–320, July 1958.

Authors discuss an approach which differs from that of Taylor in determining the entire stress-strain relation in face-centered cubic metals from experimental data in single crystals. Authors consider single crystals to be isotropic and that plastic strain increases the critical resolved shear stress of all systems, either active or latent. Thus, isotropic hardening is assumed. It is also assumed that, as the strain increases, the ratios of the components of the strain tensor remain constant. Each slip system becomes active when the elastic resolved shear strain reaches the value of the active systems.

Since only five independent components define the plastic strain tensor, only five different active slip systems need by considered. The five systems are determined by the formulation presented by the authors.

The stress-strain curve for aluminum in the plastic range determined by this method would approximate closely that of Taylor. However, the present method applies to the entire stress-strain curve and not just to the plastic region.

F. Garofalo, USA

2829. Aboav, D. A., Crystal plasticity. I. A theory of glide in metal crystals (in English), AFOSR TN (Inst. Phys., Univ. Palermo, Italy, TN 1; ASTIA AD 152 197), 61 pp., Dec. 1957.

The object of this research was to seek a simple theory of glide in metal crystals. The known facts were first classified and an attempt made to distinguish the simple, or fundamental, facts from those attributable to secondary causes. It became apparent that, while many of the characteristic glide phenomena can be attributed to a break-up or "disintegration" of the crystal lattice, others, such as the work-hardening of hexagonal metals and crystal recovery, appear to leave the lattice undisturbed, and it is with these phenomena that this work is mainly concerned.

The inadequacy of the classical theory of elasticity to account for these phenomena is briefly discussed and an attempt is made to describe them in terms of a geometrically perfect lattice whose elements are not identical. Each lattice-element is assumed to possess a characteristic property, its "state," in terms of which the internal energy, temperature and entropy are tentatively defined, and these assumptions are used as a basis for a theory of glide in metal crystals.

The theory accounts qualitatively for the main glide phenomena such as the existence of a critical shear stress, work-hardening and recovery, and predicts a creep behavior closely resembling that observed in practice. The theory also predicts a dependence of critical shear stress on crystal size.

The implications of the theory for future research are discussed and attention is particularly drawn to the importance of detailed microscopic examination of the surface of plastically deformed metal crystals. From author's summary

2830. Bilby, B. A., Gardner, L. R. T., and Stroh, A. N., Continuous distributions of dislocations and the theory of plasticity (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **8,** 35–44.

2831. Kuznetsov, V. D., 25 years of activity by the Section of Physics of Solids, Siberian Physico-Technical Institute (in Russian), *Trudi Sib. Fiz.-tekhn. In-ta Pri Tomsk. In-ta* no. 34, 3–21, 1955; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9722.

A general review, read before the Physicists' Scientific Conference held in honour of the 25-year Jubilee of the Siberian Physico-Technical Institute on 24–30 January, 1954.

Results are presented of researches on the problems of crystallization and internal friction of metals, the mechanical properties of crystals of rock salt, plasticity and strength, hardness, the cutting of metals, external friction and wear, abrasive polishing, and the influence of superficially active substances on the process of development and dispersion.

No bibliography is included. D. M. Vasil'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2832. Terminasov, Yu. S., and Tuzov, L. V., An x-ray investigation of the residual stresses of the second and third order in the deformed surface zone of a metal treated by milling (in Russian), *Ucb. Zap. Leningr. Gos. Ped. In-ta* **125,** 3–29, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 11079.

An x-ray investigation was carried out of the plastic deformation of the surface layers of steel of brand 40 when worked on by a cylindrical miller. Before treatment the samples were annealed at 750–800°. The study was carried out by Co K_α irradiation by the method of back exposures. Diaphragms round in shape and 0.6 mm in diameter were used. After being x-rayed the surface layer was electrolytically etched, then again photographed by x-ray and so on. The residual stresses of the second order were judged by the alteration in width of the interference line (310), the stresses of the third order by the alteration of the relation of the areas of the microphotometric curves, corresponding to the interference lines (310) and (220), $I_{(310)}/I_{(220)}$. The dependence of the depth of spreading of the residual stresses on some factors in the regime of treatment was discovered: (1) with increase of milling depth from 1 to 10 mm, there is a proportional increase in the depth of spread of the residual stresses, (2) an analogous phenomenon takes place when the input is increased from 0.022 mm per tooth to 0.18 mm. Authors' explanation is that in both cases there is an increase of the cutting force and, consequently, an increase in plastic deformation. It is shown that when speeds of cutting of the order of 230 m/min are reached the depth of spread of the residual

stresses attains a value of 500 μ, that is the depth of spread of residual stresses is 2.5 times as much as the depth at the customary cutting speeds. With further increase of cutting speeds from 230 to 527 m/min, the depth of penetration decreases. Authors assert that with forward feed to the cutter the residual stresses are less intensive and the depth of penetration less than in the case of counterfeeding. It appeared in all cases that stresses of the second order develop at a greater depth than stresses of the third order. Because of this the authors consider that stresses of the third order only appear in those layers of the metal where the stresses of the second order attain their determined size. It is also shown that the method of microhardness appears to be less sensitive than the Roentgenray method. The course of changes of microhardness with depth has approximately the same character as the changes of stresses in the third order. From this fact the deduction emanates that the stresses of the third order are mainly responsible for the toughening of the surface layers of the metal.

V. G. Lyuttsau

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2833. Priss, L. S., Reasons for deviation from the kinetic theory of high elasticity. Part I. Consideration of variations in the transverse dimensions of a chain during deformation of a network, *Soviet Phys.-Tech. Phys.* **3,** 3, 597–605, Nov. 1958. [Translation of *Zh. Tekh. Fiz.* **28,** 3, 636–646, Mar. 1958 by Amer. Inst. Phys., Inc., New York, N.Y.].

The proposition is stated that part of the observed divergence between experiment and the kinetic theory of high elasticity is connected with changes in the transverse dimensions of a chain during deformation of a network; such changes have not previously been taken into account and are accompanied by an entropy change. An approximate calculation is derived, the results of which are found to be in satisfactory qualitative agreement with experiment.

From author's summary

Rods, Beams and Strings

(See also Revs. 2762, 2801, 2811, 2822, 2823, 2854, 2855, 2861, 2868, 2871, 2882, 2895, 2951, 2962)

2834. Kostitsyn, V. T., The tension on a thread surrounding a cylinder with friction due to contact with the surface of the end flanges (in Russian), *Nauch. Trudi Mosk. Tekhnol. In-ta Legkoi Prom-str. sb.* 7, 156–161, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8452.

The problem is investigated of the tension on the thread encircling a cylinder and compression between flanges. From the condition of the equilibrium of forces acting on the material of the thread, a formula is deduced linking the tension forces acting on the ends of the thread. This formula differs from the known Euler formula in that it has an additional term, taking into account the flange friction.

I. I. Trapezin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Book—2835. Horejsi, J., Bars with abrupt change of cross section [Pruty s nahlou zmenou prurezu], Praha, Czechoslovakia, Stavebni Inzenyrske Prirucky, 1958, 159 pp. Cena 16.90.

Paper discusses bars with an abrupt change of the cross-section area. On the basis of Mohr's theorem, generally valid relations are presented for the calculation of support rotations (bar coefficients) α_{a1}, α_{b1} β (produced by a fixed-end moment $M = 1$) and load members α_{a0}, α_{b0} (produced by external loads). Corresponding support rotations of bars with constant cross sections are multiplied by certain coefficients. A similar method is used for the presentation of general formulas (relations) for the calculation of ordinates of influence lines of support rotations and fixed-end moments in cases of loads by external forces and also by external moments. Formulas for the calculation of coefficients which enable a simple application of the deformation method for calculations of beams containing bars with abrupt change of cross section are also included. The relations given are adapted to a possible application of the fixed-point method.

A considerable part of the treatise is devoted to tables and diagrams containing numerical values of coefficients and ordinates of influence lines. These tables can be used in practical work and much time required for the calculation of these values is saved.

Several solved numerical problems demonstrate the practical application of relations and values contained in the tables.

J. Sucharda, Czechoslovakia

2836. Rasskazovskii, V. T., Calculation for eccentrically loaded sections (in Russian), *Tr. In-ta Sooruzhenii, Akad Nauk. UzSSR* no. 6, 93–101, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 6056.

2837. Crossland, B., Jorgensen, S. M., and Bones, J. A., The strength of thick-walled cylinders, ASME Petroleum-Mechanical Engng. Conf., Denver, Colo., Sept. 1958. Pap. 58-PET-20, 17 pp.

Comprehensive pressure tests have been carried out on thick-walled, closed-ended cylinders made from a mild steel and a hardened and tempered steel, the maximum pressure reached being 94,000 lb/in.^{2} The complete theoretical behavior of the cylinders is computed from shear stress-strain data obtained from torsion tests and is shown to be in very close agreement with the experimental results. In addition, a method is given for deriving the large strain behavior of the cylinders from tension test data. When compared with the experimental results this approach gives larger errors, the theoretical values of pressure being consistently high. Finally, ultimate pressures have been calculated from two empirical expressions.

From authors' summary

2838. Axelrad, D. R., and Reichel, A., On the torsional characteristics of a shaft with multi-symmetrical curved boundary, *Austral. J. Appl. Sci.* **9,** 3, 216–224, Sept. 1958.

The multisymmetric curved boundary of a shaft is approximated by a rectilinear polygon to be able to use Schwartz-Christoffel transformation and the complex variable method for obtaining its torsion solution. It is found that the convergence of the series governing the transformation is very slow. The use of Chebyshev polynomials gives rapid convergence for a numerical solution.

B. R. Seth, India

2839. Laue, K., Method for the design of continuous beams (in German), *Bautechnik* **35,** 3, 100–102, Mar. 1958.

Book—2840. Horejsi, J., Beam on elastic foundation [Nosnik na purznem podklade], Praha, Czechoslovakia, Stavebni Inzenyrske Prirucky, 1958, 115 pp. Cena 14.80.

Work deals with the calculation of short girders placed on elastic foundations. The method of calculation is based on the influence lines of the bending moments, (M), and on shearing forces, (T).

The starting point of the treatise is Winkler's assumption according to which the girder rests on a perfectly elastic foundation fully respecting Hooke's law, i.e. a linear relation between ground pressure and girder deflection is presupposed.

The first part contains a summary of the known relations between load, deformation, and internal forces of the girder, the method of writing the differential equation of deflection and the moment curve from which the calculation starts. The conventional calculation method of a short girder is also included. In this method the short girder is assumed as being infinite in both di-

rections, and the influence of the infinite girder is added to that of the short girder both of whose end cross sections are loaded with external moments and forces. The numerical values of these moments and forces equal to the values of moments and shearing forces acting in the corresponding cross sections of the infinite girder have, however, opposite signs. The integration constants required for the calculation are determined by the boundary conditions.

In the second part the equations of influence lines of bending moments and shearing forces of the short girder are derived directly. In the case of an elastically supported girder these equations are derived according to Maxwell's theorem and the principle of superposition. The sought-for influence lines are thus obtained as deflection lines of a girder loaded by the corresponding impulse of deformation.

A rapid calculation of bending moments (M) and shearing forces (T) of short girders placed on elastic supports is made possible by the tables A which contain numerical values of ordinates of influence lines M and T for the most frequently occuring "dimensionless" girder-length of $\lambda = l/r = 0.2$ to 4. The application of these influence coefficients is demonstrated by an example. This example serves also as a comparison between the conventional calculating method of short girders and the method proposed in the article. Ordinates of influence lines used in the example are arranged in tables.

In cases of girders with very high bending stiffness the girder may be considered as very short (in the sense of "dimensionlessness") or practically stiff (perfectly stiff) and individual sections of the influence lines are formed by straight lines.

The third part deals with the calculation of bending moments, shearing forces, and deflection lines caused by an irregular change in temperature. Integration constants are calculated for several systems of supports. Auxiliary coefficients facilitating the calculation are given in tables.

J. Sucharda, Czechoslovakia

2841. Simvoulidi, I. A., An approximate method of analysis of beams supported on an elastic foundation (in Russian), *Sb. Trudi Mosk. Inzb.-stroit. In-ta* no. 14, 187–200, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9543.

An approximate method is suggested for the analysis of beams supported on an elastic foundation, based on representation of the reactive pressures $p(x)$ by a polynomial of the third order. In the case of the foundation, the equations of the two-dimensional case in the theory of elasticity are applied. The following conditions are applied to the determination of the coefficients of the polynomial: identical flexure and sinking of the foundation, at the left-hand end and in the middle of the beam respectively; equality of the areas formed by the deflection of the beam and foundation respectively; and equality of the third derivatives of the deflections and sinkings in the central point. As an illustration, solutions are given for several particular problems, and the results are compared with the more accurate results obtained by other authors.

P. I. Klubin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Plates, Shells and Membranes

(See also Revs. 2781, 2795, 2799, 2800, 2809, 2837, 2860, 2865, 2866, 2895, 2951, 3109)

2842. Zlokovic, D., Moments at the center of elastic plates due to uniformly distributed loads, *Naše Gradevinarstvo* **12,** 1, 34–40, Jan. 1958.

Presented analysis and tabulated values refer especially to reinforced-concrete slabs of rectangular shape freely supported at the periphery and restrained along various number of edges, considering load concentration at the center.

J. J. Polivka, USA

2843. Nemirovskii, Ya. M., Calculations for plates on an elastic foundation while taking into account the rigidity of the structure and the stage (reached) of equilibrium limit (in Russian), *Sb. Tr. Mosk. Inzb.-stroit. In-ta* no. 14, 201–215, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 11010.

The results of calculations are analyzed for a ferro-concrete round plate, typical for the foundation of a blast furnace. Comparisons are made of the calculations for the theory of elastic semi-spaces, without and with consideration for the real rigidity of the plate, and by the method of equilibrium limit. A numerical example is given which illustrates the economical nature of the calculations by the last two ways. The view is expressed on the possibility of arriving at a still more economical calculation based on experimental data obtained while studying the plastic properties of soils.

P. I. Klubin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2844. Min-Yuan, M., Calculation of conical rotational shells with bending load. Parts I and II (in French), *Ann. Ponts Chauss.* **128,** 1, 87–113, Jan./Feb. 1958; **128,** 2, 175–230, Mar./Apr. 1958.

The conical shells are bounded by two cross sections perpendicular on the axis (truncated cone) or by the vertex and one such cross section (complete cone). The vertex angle is 2α, the thickness is constant. Author states that though the problem has previously been solved exactly, the resulting formulas often lead to extremely lengthy computations. After giving an elaborate description of some known results, two particular cases are further dealt with by means of series developments. These cases are the very flat complete or truncated cone ($\pi/2$-α small) and the sharp cone (α small). The range for the validity of the results for the flat cone remains limited. The range of validity of the results for sharp cones is sometimes, depending on the ratio thickness to overall dimensions, remarkably large, especially for the truncated cone. It is the intention of the author that his formulas, giving influence coefficients, cover the cases occurring in practice. Numerical results are compared with those of Taylor and Wenk [AMR **9** (1956), Rev. 710].

J. P. Benthem, Holland

2845. Ramaswamy, G. S., Research on a new doubly curved shell. Part I. The theory of a shell in the form of a Prandtl membrane, *Civ. Engng., Lond.* **53,** 626, 899–900, Aug. 1958.

Purpose of paper is to find a suitable form for precast rectangular concrete shell roof units with a span of some feet. The unit consists in a shallow concrete shell fitted in a horizontal reinforced-concrete frame. Under uniformly distributed load, uniform compression state of stresses in the shell is desired. Assuming this, the shell takes a form which is identical with that of the soap film in Prandtl's membrane analogy for solving torsion problems. For a rectangular boundary, the analytical form of the membrane is known from the solution of the corresponding torsion problem; so this solution can be used for checking the correct form of the cast shell. Author points out that the new type of shell, being wholly under a predetermined and very low compression unaccompanied by tension or shear, needs no reinforcement, and a cheap composition of concrete can be used.

E. Monch, Germany

2846. Ramaswamy, G. S., Chetty, S. M. K., and Bhargava, R. N., Research on a new doubly curved shell. Part 2. Casting and testing a shell roof unit, *Civ. Engng., Lond.* **53,** 628, 1155–1157, Oct. 1958.

A concrete shell roof unit, whose theory was given in a former paper (see preceding review), has been developed for India's low-

cost housing program. Inexpensive manufacture, easy manual handling, and use of a minimum of critical materials—cement and steel—were essential. Casting process consists in making the shell "cast itself." The concrete is poured over a piece of strong cloth (hessian) which, after sagging down, gives the shell the required form. A cheap mixture of concrete can be used, in most cases without reinforcement. Static and shock-load tests of units of 4 ft × 4 ft, 1 inch thick, gave highly satisfying results. A full-scale roof of 12-ft span incorporating the units was also tested successfully. E. Monch, Germany

2847. Ramaswamy, G. S., Chetty, S. M. K., and Parthasarathy, M. R., Research on a new doubly curved shell. Part 3. Practical uses of shell roof units, *Civ. Engng., Lond.* **53,** 629, 1278–1279, Nov. 1958.

The type of shell described in the previous articles (see two preceding reviews), which was primarily developed as a low-cost roof for rural housing, is equally satisfactory for use as a roof or floor of single-storied or multistoried buildings. Therefore authors have developed additionally: shells spanning between precast reinforced-concrete planks, shells cast with monolithic ribs, shells with reinforced-concrete edge beams, and cast-in-situ shells with prestressed edge beams. Moreover, an analysis of deformations of the edge beams and their influence on the stresses in the shell, which was not given in the theory of the first paper (Rev. 2845), is presented. E. Monch, Germany

2848. Rozenblyum, V. I., Design of a T-shaped tail of a turbine blade using plastic analysis (limit design) (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 5, 122–126, May 1957.

Statically admissible, discontinuous stress field in a tail of a turbine blade is discussed, assuming plane flow problem of ideal plastic material. Properties of a discontinuous stress field and those of discontinuity lines [A. Winzer and F. G. Carrier, *J. Appl. Mech.* **15,** 261–264, 1948] have been used to evaluate proper geometry of a tail, from the theory of limit analysis point of view. Velocity field has not been analyzed.

A. Sawczuk, Poland

2849. Ionov, V. N., The equilibrium of an elastic, thick-walled tube under the action of an internal pressure, over a section of length 2c (in Russian), *Vestnik Mosk. In-ta* no. 5, 13–24, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9271.

The stress and strain condition is examined of a thick-walled elastic tube of infinite length, loaded by a radial force uniformly distributed over the circumference. The solution is obtained in Bessel functions. For a tube of great (wall-) thickness, relatively simple, asymptotic expressions are given for the stresses.

The solution obtained for the annular load is extended to the case when the tube is loaded with a uniform pressure over a section of finite length. S. V. Boyarshinov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2850. Shtalev, B. A., Formulas for the calculation of rings (in Russian), *Vestnik Mash.* **36,** 6, 25–29, June 1956.

2851. Heyman, J., Plastic design of rotating discs, Instn. Mech. Engrs., Prepr., 13 pp.

A design procedure is presented which is based on collapse speed. This is defined as the speed at which the entire disk becomes plastic, and corresponds to a state of instability for the non-strain-hardening materials considered. Various profiles are investigated. As his design criterion, author uses an overspeed factor applied to the collapse speed instead of a safety factor on stress. This approach leads rapidly to design results, some of which are compared with elastic calculations for the low-pressure disks of a steam turbine. Reviewer notes that for actual materials [AMR **6** (1953), Rev. 3367] bursting strains can be less than those required for instability. L. Maunder, Scotland

2852. Sololov, V. I., Design of seperator rotors based on allowable stresses and safe loads (in Russian), *Vestnik Mash.* **36,** 6, 17–20, June 1956.

2853. Suchar, M., Computation by means of polynomials of influence surfaces for anisotropic plates with finite dimensions (in English), *Arch. Mech. Stōs.* **10,** 5, 615–634, 1958.

Author develops a fine theory of special polynomials constituting a complete set of regular solutions of the equation for the deflection surface of an anisotropic plate. The polynomials can be used for determining the regular parts of the influence surfaces. Quasi-biharmonic polynomials used in the theory of orthotropic plates are shown to be a special case of the author's general conception.

The case treated is an orthotropic plate in the form of a parallelogram simply supported on two edges, the remaining sides being free; two of the edges are parallel to one of the principle directions of elasticity.

The paper is of considerable theoretical character and cannot be read without adequate knowledge in mathematics. Its significance for the mechanics of continuous media is evident—such kind of scientific literature needs no recommendation.

V. Vodicka, Czechoslovakia

2854. Clarkson, J., Elastic analysis of a beam-plating structure under a single concentrated load (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6,** 176–186.

The problem considered is the elastic rectangular plate strengthened by parallel, evenly spaced longitudinal beams and subjected to a single concentrated load applied perpendicular to the plane of the plate at the mid-span of one beam. Differential equations and boundary conditions are set up and a solution found in terms of infinite series. Calculations are presented for (1) single beam with plate flange of width equal to beam spacing (simple beam theory), (2) analysis neglecting plate bending stiffness, (3) analysis allowing for plate bending forces and forces in plane of plate, and (4) analysis of H. L. Cox [U. of Ill., Civ. Engng. Studies, Structural Research Series, no. 60, Aug. 1953]. Results are in reasonably good agreement with tests on models.

A. G. H. Dietz, USA

2855. Nowinski, J., States of stress in an orthotropic thick-walled tube surrounded by an elastic medium (the Galerkin problem for an orthotropic material) (in English), *Arch. Mech. Stōs.* **9,** 2, 217–226, 1957.

Four cases are studied: temperature or internal pressure expansion restrained both radially and axially, or radially alone. In all four cases the tube is cylindrically orthotropic so that the cases studied are axisymmetric. A numerical example of a heated reinforced-concrete tube restrained radially but not axially is solved. As expected the tangential and radial stresses are made more compressive by the restraining medium. The axial stresses are not affected at all.

Reviewer believes that the effect of orthotropy should have been discussed. N. C. Costakos, USA

2856. Mikeladze, M. Sh., Rigid-plastic bending of anisotropic nonsymmetric circular plates (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 2, 72–76, 1957.

Author considers the rigid-plastic bending of anisotropic circular plates of asymmetric profiles. Starting in a way analogous to that in a classical approach, i.e., from the relation between the radial and circumferential deformations and the velocity of the translation, author derives the fundamental differential equation of the problem in question. Using a qualitative approach, Mike-

ladze establishes the lower and the upper limit of the admissible loading intensity. The technique is illustrated on a particular example of a plate of a constant slope of profile asymmetry, with the ratio of the limits being equal to 1.15.

M. Z. v.Krzywoblocki, USA

Buckling

(See also Revs. 2777, 2933)

2857. Lin, Y.-K. M., Approximate buckling loads of open columns, *Proc. Amer. Soc. Civ. Engrs.* **84,** EM 4, (*J. Engng. Mech. Div.*), Pap. 1793, 22 pp., Oct. 1958.

Author develops general equations, by means of energy method, to determine buckling load and mode shape for column of open section of arbitrary shape. Loading is assumed to be axial with arbitrary location of line of thrust. Theory includes effects of bending and nonuniform torsion. Variety of end conditions are studied in the paper. Paper is clearly written; method and results should be of value to structural engineers. H. J. Plass, USA

2858. Gemmerling, A. V., and Klimov, N. I., Carrying capacity of centrally and eccentrically compressed rods made of steel mark NL2 (in Russian), Issledovaniya Postal'nym Konstruktsiyam, Moscow, 1956, 68–96; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8244.

A study is made of the strength of eccentrically compressed rods fastened by means of hinges made from steel mark NL2, for deflection in the power plane, coinciding with the plane of symmetry. Jezek's assumptions [K. Jezek, *Stahlbau* 1933] are adopted (retention of the norms, idealization of the stress-strain curve along the semi-wave of the sinusoid, replacement of the curve of the second derivative). The transverse section composed of three rectangles is examined. With unilateral flow the criterion of stability losses is recorded in the form

$$\frac{dM}{da} = \frac{dM_N}{da} \qquad [*]$$

where M and M_N correspond to the interior and exterior forces in the mean section respectively, a is the depth of the elastic region of the section. As is known, when these assumptions have been put into effect, equation [*] becomes the equivalent of the stationary condition of the value of the compression forces. Tables are given for the values $\varphi = \sigma_{cr}/\sigma_r$ for some types of section. The results are brought in for tests of 14 rods of double T section. In the case of eccentricity in the plane of the wall, the deflection-torsion form of stability loss was investigated. In the case of eccentricity in the plane of smallest rigidity, the divergence between the theoretical and experimental data did not exceed 10%.

B. M. Broude

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2859. Kachanov, L. M., Stability of thin-walled columns in the elasto-plastic range (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **107,** 6, 803–806, Apr. 1956.

Using the tangent modulus approach of Shanley, author derives general equations for the stability of thin-walled columns. For the I-beam in pure bending his equations reduce to those of Flint [*J. Mech. Phys. Solids* **1,** 90, 1933]. I. Finnie, USA

2860. Eid, A.-R., Buckling of trapezoidal plates (in German), *Mitt. Inst. Baustat., ETH, Zurich* no. 31, 96 pp., 1957.

Author presents comprehensive solution of bending and buckling of symmetrical trapezoidal plates. The applicable plate equation $\nabla^4 w = p/D$ and slab equation $\nabla^4 F = 0$ (F = Airy's stress function) are solved numerically, using standard finite difference equation techniques.

Solutions for uniformly distributed normal loads and end forces applied on parallel faces in plane of plate are combined to derive buckling conditions under normal loading. Only simply supported edges are considered, with numerical results presented for side ratios of 1 and 2. The last section presents treatment for arbitrary load by superposition of symmetric and antisymmetric distributions. Formulas are given for determination of critical stress under combined bending and compression.

N. A. Weil, USA

2861. Guillot, R., Buckling of arches and beams of variable inertia (in French), *C. R. Acad. Sci. Paris* **246,** 5, 701–704, Feb. 1958.

The problem has been treated by several authors for constant and variable inertia (laws $I = I_{crown}/\cos\varphi$ or $I_{crown}/\cos^2\varphi$) employing: (a) method of Adams-Störmer for the integration of the differential equation, (b) finite differences or variational methods, (c) the well-known old method of Engesser-Vianello. The results are given in simple form by Kollbrunner-Meister [Knicken, Berlin, 1955, pp. 194–195]. The German Norm DIN 4114 contains also some prescriptions for the critical thrust (chap. IV).

Author proposes a new way using confluent hypergeometric functions. He analyzes the questions in a general manner and in particular a hingeless parabolic arch of inertia $I = I_{crown}/(1 - k \cdot \chi^n/a^n)$, without a determination of the coefficients in the final equation. In absence of tables of hypergeometric functions, they are developed by canonical series. The solution is of interest.

A. M. Guzman, Argentina

2862. Toryanik, M. S., The three-dimensional stability of an abutment-hinged arch with elastic joints (in Russian), *Nauch. Zap. Poltavsk. In-ta Inzh. S.-kh. Str-va* no. 3, 148–172, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9501.

Results are presented of theoretical and experimental investigations on the loss of stability of elastic arches with horizontal tie-rods. The analytical solutions, presented in general form for $I_\omega \neq 0$, have been obtained by the static method, the influence of the elastic joints being replaced by the action of an elastic medium. The particular tests in question (over 180) were made on models of arches (l = 1.6-5 m; f/l = 0.1 to 0.4) made of strip steel 30 × 4 mm, and angles of 30 × 20 × 4mm; the ties being of strip steel 20 × 4 mm and 30 × 4 mm. The experiments have confirmed the abrupt increase in the stability of an arch with effective ties (case of loading of a single arch of a span of several arches, connected by horizontal tie rods). The experimental, numerical values are correlated with the analytical results. (Divergence is from 0 to 9%.) A. A. Pikovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2863. Hoffmann, Sh. M., The approximate calculation of the stability of freely supported frames by the method of replacing the matrix of the coefficients by the matrix of the radial structure (in Russian), *Trudi Tashkentsk. In-ta Zh.-d. Transp.* no. 5, 187–203, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9524.

The analysis is founded on the fact that in certain cases it is possible to replace the matrix of the characteristic determinant by a matrix in which all extra-diagonal elements have zero value excepting the elements of one line and the column corresponding to the displacements of the frame. Such a matrix is termed "the matrix of the radial structure." This conception is generalized for lattice matrices.

A number of examples are given to demonstrate that neglecting the values of the extra-diagonal elements may lead to a small error in the calculation of the "critical parameter"—the natural number. For the calculation of the latter, a "trial and error"

method is suggested. The problem of evaluating the trial cases is not touched on.

L. K. Narets

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2864. Belyayev, B. I., Loss of stability in steel structures (in Russian), *Stroit. Prom-st'* no. 12, 25–31, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9599.

Characteristic cases are examined of the loss of stability in steel structures, followed by an analysis of the causes of failure. The model of the bottom of a water-tank in the form of a truncated cone, compressed in two, mutually perpendicular directions, failed at stress values several times less than those determined in the design calculations. The upsetting of a line of power pylons took place, essentially, by local failure of the angle gussets of the latticed leg working in compression, with a K-arrangement of the lattice members.

Roof trusses failed under snow loads, by loss of stability of the compressed truss members, the section of which had been weakened, compared with the design scantlings.

N. K. Snitko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2865. Kempner, J., Recent results in the theory of large deflections of cylindrical shells (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6**, 242–249.

Results of several finite-deflection analyses of postbuckling behavior of thin elastic cylindrical shells are summarized and evaluated. Both axial compressive as well as hydrostatic loadings are considered. For axially compressed shells, dead-weight loading indicates an axial stress in the postbuckling region equal to 30% of the classical small-deflection value, whereas for rigid testing machine loading the result is 35% of the classical value. These results hold for initially perfect shells. For the case of hydrostatic loading, postbuckling pressures slightly less than the classical value are found only for relatively short shells. The presence of axially symmetric initial imperfections greatly reduces the buckling pressure.

W. A. Nash, USA

2866. Kozarov, M., An investigation of the stability of a thin, elastic and orthotropic envelope by the nonlinear theory of V. Z. Vlassov, Part I (in Bulgarian), *Stroitelstvo* **3**, 5/6, 31–35, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9303.

The stability is examined of a closed, circular, orthotropic, cylindrical shell, under conditions of compound stress (axial compression, bending and torsional moments, and radially transverse pressure).

Known formulas are given to express the strains and stresses in the envelope. From these, the conditions for continuity of deformation are set up.

Next, the fundamental variational equation is derived, from which, on the assumption that the variations of the derivatives δu, δv, δw are arbitrary and independent values, the author derives the equation of equilibrium for an orthotropic, cylindrical envelope (shell).

Applying a generalized form of stress function in the equilibrium equation, for the case of an orthotropic envelope, author reduces the problem to a system of two particular nonlinear differential equations, describing the stability of a thin-walled, orthotropic, circularly-cylindrical, elastic envelope, applying corresponding static and geometric boundary conditions.

These equations are further developed for the case of initial flexure of the envelope.

The possible forms of loss of stability are discussed, as well as the suitable selection of the displacement functions u, v, w in the case of loss of stability of the envelope.

The problem of determining the upper limit of critical stress of an orthotropic, circular, elastic cylindrical envelope under compound loading is examined. The result of this analysis is an extremely complicated, general formula, linking the value of the critical peak stress with the physical and geometric characteristics of the particular envelope. All known particular cases can be derived from the last-mentioned formula.

R. G. Surkin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Vibrations of Solids

(See also Revs. 2775, 2778, 2881, 2891, 2902, 2969, 3152)

2867. Yushchenko, A. A., Longitudinal vibrations of a thread with a variable mass at its end (in Russian), Avtoref. Diss. Kand. Fiz.-Matem. Nauk, In-ta Matem. Akad. Nauk USSR, Kiev, 1957, *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10840.

2868. Gakkel', Finding numerical values for the roots of an equation for the frequencies of natural vibrations of rods in tension and compression with rigidly fastened ends (in Russian), (Soobshch-N.-i. In-ta Mostov Pri LII Zh. **15**). Moscow, Transzheldorizdat, 1954, 12 pp., illus., gratis; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10837.

2869. Grinberg, S. M., The natural bending oscillation frequencies of tapered rods (in Russian), Oscillations in turbine machinery, Moscow, Akad. Nauk SSSR, 1956, 96–110; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9384.

In the presence of an exponential law of change of the section moments of inertia along the length of the rod, the solution of the equation of the oscillations is expressed in Bessel functions. The frequencies and modes of natural oscillation in the first five harmonics are determined for two types of boundary conditions.

I. E. Sakharov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2870. Galustian, S. B., Construction of the Green function for the equations of oscillation of a bar (in Azerb.), *Trudî Azerb. Industr. In-ta* no. 13, 63–74, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9378.

A review of the essential facts relating to the uniform boundary problem of the equation $v^{IV} - \lambda\rho(x)v = 0$, and construction of the Green function for a number of particular cases.

V. V. Bolotin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2871. Leiderman, Yu. R., A method of investigating parametric resonance (in Russian), *Trudî In-ta Sooruzhenii Akad. Nauk UzSSR* no. 6, 68–80, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4667.

For Hill's equation

$$\frac{d^2y}{dt^2} = -\lambda A(t)y(t)$$

where $A(t)$ is an arbitrary periodic formation of period π, a method is suggested for finding the periodic solutions, consisting in reducing the problem to a Fredholm integral equation. Using the known methods of determining the eigen numbers and functions, author obtains approximate estimates for λ in the case corresponding to elastic oscillations of a beam, and distinguishes the first region of unsteady motion, verifying the known result of N. M. Belyaev ["Stability of prismatic rods under the action of

variable longitudinal forces;" in "Engineering plant and construction mechanics," Leningrad, Izd-vo "Put'" 1924].

N. A. Rostovtsev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2872. Sherwood, J. W. C., Propagation in an infinite elastic plate, *J. Acoust. Soc. Amer.* **30,** 10, 979–984, Oct. 1958.

At any single frequency an infinite elastic plate is expected on general grounds to have an infinity of eigenvibrations. Previous work has shown only a finite number, with real or imaginary propagation constant. This investigation yields an infinity of two-dimensional eigenvibrations with complex propagation constants (exponential attenuation, finite phase velocity). The probable structure of the complete mode system for low frequencies is hypothesized for Poisson's ratio 0.31. There is an equivalent set in which each mode is constant in phase, with an amplitude variation which is the superposition of an exponential and a sinusoid. From author's summary by P. Rudnick, USA

2873. Belley, G. A., The torsional bending vibrations of turbine blades (in Russian), *Trudi Stud. Nauch. O-va Kharkovsk. Politekhn. In-ta* **1,** 1, 7–15, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9675.

The combined torsional and bending vibrations of a blade rigidly held at one edge are considered. The amplitudes of bending and the torsional angle about the center of bending are represented in the form of exponential series.

A numerical example is given of the calculation of the two first sections of the blade; as is usual, the frequency of vibration is found to be lower than the pure bending frequency of vibration of the blade. E. I. Grigolyuk

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2874. Freese, C. E., Vibration of vertical pressure vessels, *ASME Trans.* **81B** (*J. Engng. Indus.*) no. 1, 77–91, Feb. 1959.

This paper is primarily concerned with the vibration of vertical pressure vessels known as columns or towers.

The procedure for estimating the period of the first mode of vibration for columns which are the same diameter and thickness for their entire length is outlined. A graph is included for this purpose which recommends limits between vessels considered to be static structures and those considered dynamic.

A method for designing vessels considered as dynamic structures is described as well as a detail procedure for estimating the period of vibration of multi-thickness (stepped shell) vessels and/or vessels built to two or more diameters with conical transitions *where the difference in diameter is small.*

There is a brief résumé of the "Karman vortices" effect and a discussion regarding vibration damping by liquid loading and the benefit of ladders and platforms which help reduce the effect of periodic eddy shedding.

The design procedure outlined will be useful to the practical vessel designer confronted with the task of investigating vibration possibilities in vertical pressure vessels.

From author's summary

2875. Neuber, H., and Bufler, H., The determination of the eigenfrequencies of locomotives (in German), *Z VDI* **100,** 14, 587–591, May 1958.

Problem is of interest for engineers engaged in the subject of vehicle vibrations.

An undamped linear model representing a locomotive-support-system is analyzed by means of the Langrangian equations of motion. Due to the model chosen the decoupling of the eigenfrequencies is reached to a high degree. The rather complicated kinematic conditions governing the motion between wheel and rail are replaced by a linear spring system.

For determining the eigenfrequencies the fourteen-by-fourteen determinant splits up in subdeterminants, the highest of these being a three-by-three determinant. The combination of the derived frequencies should give good information about the modes of vibrations observed in operation. A. Slibar, Germany

2876. Moskvitin, V. V., Longitudinal vibrations of an elastoplastic system with a finite number of degrees of freedom (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk*, no. 2, 77–84, 1957.

Moskvitin considers the longitudinal vibrations in a system of elastoplastic nature with a finite number of degrees of freedom. Beginning with the stress-strain relation and the dynamic equation of motion (Newton's law), he derives the differential equation (ordinary, second-order) of the vibrational motion. A general solution of this equation is found in the usual way, i.e., through the association with a system of algebraic equations and equating the determinant to zero. Obviously, an oscillatory character of the acting load is chosen and the usual relation between the translation and the velocity is fully applied. The method of the construction of the solution is demonstrated on examples of systems with one and three degrees of freedom. Moreover, author studies the possibility of a resonance in such systems.

M. Z. v.Krzywoblocki, USA

2877. Murakami, M., Vibration of water turbine when air is admitted to its draft tube (experimental study), *Bull. JSME* **1,** 3, 298–304, Aug. 1958.

This experimental study revealed that the severest vibrations in the draft tube of water turbines can be eliminated or greatly reduced by the admission of air into the draft tube; but unless just the right amount of air is admitted, instead of reducing vibration, a large amount of draft head is destroyed and, conversely, vibrations are increased. To verify this fact, author used models of draft tubes. He obtained the relations among amplitude of vibration, flow ratio of air to water, draft tube efficiency, and ratio of circulatory component to axial component of water. Here the optimum amount of water to be admitted is studied and results are presented graphically. From author's summary

2878. Chetaev, N. G., Certain questions concerning the motion of vibration mills (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 3, 49–56, Mar. 1957.

The cycle of operation of vibration ball mill is divided in three parts: (1) load and container moving upward as one body; (2) load and container moving downward as two separate bodies; (3) impact of load on container.

Basic relations of governing factors for these movements are derived from general equations of dynamics under many assumed simplications of the problem. An approximate solution of the equations is given and results are compared with values from German experiments (source quoted).

Conclusions are proposed regarding certain general relations for the design and operation of the mill.

W. de O'Byrn, England

2879. Duffy, J., and Mindlin, R. D., Stress-strain relations and vibrations of a granular medium, *J. Appl. Mech.* **24,** 4, 585–593, Dec. 1957.

Stress-strain relations and longitudinal wave velocities are derived for a face-centered cubic array of elastic spheres. Both normal and tangential contact forces between spheres are considered. Normal forces are computed from the theory of Hertz and tangential forces are computed from theories by Catteneo, Mindlin and Deresiewicz. Stress-strain relations for the array are derived from: (1) the requirement that equilibrium be maintained by contact

forces between spheres as a result of increments of force applied to the array, and (2) the requirement that relative displacements of sphere centers be compatible. Because the relation between the tangential contact forces and the displacements of the spheres is inelastic, the nonlinear stress-strain relations of the array depend on the loading history of the array.

Longitudinal wave velocities in (1, 0, 0) and (1, 1, 0) directions are derived and the results are applied to a face-centered cubic array of steel balls. Theoretically derived wave velocities show close agreement with experimentally determined velocities. However, experimental rates of energy dissipation are proportional to the square of the maximum tangential contact force rather than to the cube as predicted by theory.

Experimental velocities are determined by measurement of the resonant frequencies of bars constructed of steel spheres and subjected to net frame pressures ranging from 2 to 14.7 psia. The interstices of the bars are evacuated. The lengths of the bars are equal to approximately 40 sphere diameters. Theoretical and experimental wave velocities are presented as functions of pressure on the bars, and the rates of energy dissipation are presented as functions of the amplitudes of displacement of the ends of the bars.

H. Brandt, USA

2880. Karapetian, B. K., An experimental investigation of the internal friction in stone masonry (in Russian), *Izv. Akad. Nauk ArmSSR Fiz.-Matem., Estestv. i Tekhn. Nauk* **9**, 8, 69–83, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9638.

Experiments on samples of ashlar and brick masonry are described. In the dynamic tests, the logarithmic fading decrements were investigated; in the static tests, the area of the hysteresis loop. The experiments confirm the coincidence between coefficients of fading determined directly from the oscillations of the sample and those from the hysteresis loop plotted from the static tests. As a result of these experiments it is found that the logarithmic fading decrement of masonry increases with increasing bending stress and decreasing compression stress, and is practically independent of the period of natural vibration of the masonry. Some numerical values of the decrement are presented.

K. S. Zavriev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Wave Motion and Impact in Solids

(See also Revs. 2872, 2879, 2891, 2967)

2881. Buchwald, V. T., Transverse waves in elastic plates, *Quart. J. Mech. Appl. Math.* **11**, 4, 498–508, Nov. 1958.

Plane rotational waves in elastic plates with displacement vector parallel to the surfaces of the plates and perpendicular to the direction of propagation are studied. In a double plate there appear two types of transverse waves the behavior of which is illustrated by dispersion curves, computed for the lowest modes. A discussion on the properties of Love waves in a surface layer as well as numerical results are finally presented.

P. P. Teodorescu, Roumania

2882. Takata, M., Dynamic bending of drilling rod, *Bull. JSME* **1**, 2, 124–129, June 1958.

The dynamic bending stress and moment of an initially curved elastic bar subjected to an axial impact by a rigid mass are analyzed approximately and the results are applied to a rod of rock drill. The analytical results agree fairly well with the experimental results, qualitatively as well as quantitatively. It may be said that in the drilling rod the bending stress due to initial deflection is small, but the one due to the eccentric blow is rather large compared with the longitudinal stress, the main one. These bending stresses increase linearly with the impact velocity and initial deflection or eccentricity of the blow. They are also affected by the mass of the striking body and the slenderness ratio of the rod. The peaks of the stress distribution stand near to the ends.

From author's summary

2883. Chadwick, P., and Sneddon, I. N., Plane waves in an elastic solid conducting heat, *J. Mech. Phys. Solids* **6**, 3, 223–230, May 1958.

In this paper the influence of thermal effects on the propagation of waves in an isotropic thermoelastic solid is examined. It is proved that the thermal effects do not influence the shear waves; on the contrary they cause two distinct dilatational waves, one having the nature of an elastic longitudinal wave and the other that of a thermal wave.

Authors, taking ω^{*-1}, U_p/ω^*, $[\lambda + 2\mu/\rho]^{1/2}$ as units corresponding to time, length and velocity, give the basic equations of thermoelasticity in dimensionless form and then by the equations

$$\nabla^2\omega = \beta^2 \frac{\partial^2\omega}{\partial t^2}, \quad \beta^2\nabla^2\Delta - b\nabla^2\Theta = \beta^2 \frac{\partial^2\Delta}{\partial t^2}$$

Applying the above results to the harmonic plane waves they seek solutions in the form

$$\Delta = \Delta^\circ \exp[i\omega t + p(a\cdot r)], \quad \theta = \theta^\circ \exp[i\omega t - p(a\cdot r)]$$

The values of p of those equations are the roots $\pm p_1$, $\pm p_2$ of the equation

$$p^4 + p^2[\omega^2 - i\omega(1 + e)] - i\omega^3 = 0$$

Those roots are found approximately by expanding in powers of $\omega^{-1}(\omega > 1)$ and $\omega(\omega < 1)$. There follows an investigation of the roots, and the phase velocity v of the waves as well as the attenuation coefficient q are defined for the cases $\omega > 1$, $\omega < 1$, $\omega = 1$.

Authors give in tables the values of ω^*, vp, e, q_∞ and $L_1\omega^2$ for the metals Al, Cu, Fe, Pb. It is proved by the values of the tables and the corresponding curves how v and q behave in each medium in the neighborhood of ω^*. The ratio $(\lambda + 2\mu)_d/(\lambda + 2\mu)_s = 1 + e$ is also calculated, which is dynamic to the static value of $\lambda + 2$ for the four metals.

Authors deal with a difficult subject in which research was done by Deresiewicz and Lessen recently, and have given a notable contribution to these researches.

C. P. Papaioannou, Greece

2884. Togunov, Yu. V., The application of an approximate method of determining the shock-wave pressure as a criterion of the degree of comminution (in Russian), *Sb. Nauch. Trudi Magnitogor. Gorno-metallurg. In-ta* no. 9, 58–68, 1955; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 8705.

The purpose of the work is the theoretical analysis of the mechanical action of a shock wave propagating through blasted rock strata. Determination of the pressure behind the shock-wave front is performed by G. I. Pokrovsky's approximation. This formula is valid for spherical waves, and is slightly modified here to extend it to the case of the powerful explosion of an elongated charge. The possibility is investigated of applying the same formula to determine the size of charge required in mining operations. Having demonstrated the necessity for a revision of the said formula, author fails to give any concrete suggestions in this regard.

V. P. Shidlovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2885. Petrasen, G. I., On a rational method for solving problems of dynamical theory of elasticity in the case of isotropic layers with plane-parallel boundaries of separation (in Russian), *Leningrad Gos. Univ. Uchen. Zap. 208, Ser. Mat. Nauk* **30**, 5–57, 1956.

This is a most valuable review of Russian work on the solution of dynamical problems in the mathematical theory of elasticity in the case of isotropic solids with plane (and parallel) boundaries. It discusses in great detail the method of contour integrals (or incomplete separation of variables) due to Petrasen himself.

After a brief reference to the classic work of Rayleigh and Lamb, the work of Sobolev and Smirnov on the derivation of "functional-invariant" solutions is touched upon. The main part of the paper is devoted to the discussion of the method of contour integrals; as author points out, this differs from the method of Fourier transforms only in that the integration with respect to the parameter multiplying the time variable is carried out, not along the real line, but along a contour in the complex plane.

The paper begins (§ 1) with the formal construction of solutions of the equations of dynamical elasticity in the plane and in the case of axial symmetry. In § 2 asymmetric problems are considered. The third section is concerned with a discussion of the mathematical foundations of the theory previously constructed. In this section author not only describes his previous work on the solution of particular problems, but justifies the method employed with a good degree of generality. In the last section of the paper, some auxiliary results are derived which are essential for the study of wave fields in isotropic elastic solids.

I. N. Sneddon, Scotland
Courtesy of Mathematical Reviews

2886. Ryabova, E. V., The problems of the impact of a wedge on a cord (in Russian), Vestn. Mosk. In-ta no. 1, 57–62, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9445.

It is demonstrated that the problem of the impact of a wedge of finite mass on an infinitely long flexible cord can be reduced to the solution of three equations in partial derivatives in two different regions with given conditions at the boundaries of the regions, these region boundaries—the wave of forcible rupture and the wave of recovery—being unknown. In the case of elastic-plastic deformations, solution is suggested by the method of characteristics. For the case of elastic deformation, the solution is conducted to a determination by the method of successive approximations.

Paper contains references to bibliographical sources but, by some misunderstanding, the bibliography at the end has been omitted.

G. S. Shapiro
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Soil Mechanics: Fundamental

(See also Revs. 2764, 2843, 2902, 3146)

2887. Wroth, C. P., Soil behavior during shear. Existence of critical voids ratios, *Engineering* **186,** 4829, 409–413, Sept. 1958.

A method for presenting results of shear tests in three-dimensional form is described.

It is possible to predict the complete three-dimensional test curve, provided the initial conditions and degree of drainage are known, and provided the yield surface for a particular soil has been established. Procedure for developing the yield surface is described. Test paths end at points which define a line on the yield surface. At any point along the line, the sample is in a state of critical voids ratio, and further unlimited deformation can take place with the values of shear stress, voids ratio, and principal effective stress or normal stress, remaining unchanged. The method applies to a wide variety of granular soils, both cohesive and cohesionless.

F. J. Converse, USA

2888. Henri, M., Virtual stresses and the surface of a weak sliding resistance inside a massive body (in French), *Ann. Inst. Tech. Bat. Trav. Publics* no. 120, 1384–1402, Dec. 1957.

Original method is presented determining the virtual stresses which could exist within a soil body made from a granular material or a material of weak cohesion. Simple procedure is shown of determining which of the various modes of equilibrium compatible with boundary and loading conditions is associated with the least strain energy and consequently would be the least stable. Shape and location of the sliding surface along which the sliding resistance is a minimum is determined from the magnitude and direction of principal stresses. Conventional analysis assumes the ratio of tangential to normal stresses in each point of the sliding surface to be identical, whereas author's method considers its actual variation. New method permits examination as to what extent the principal stresses in the immediate vicinity of the slope or any other surface free from external forces are compatible with the mechanic properties of the material and with properties of the supporting body along or below the sliding surface. The bearing capacity of the body can also be determined in terms of critical overburden and the weight of the body mass which would come into motion if a sliding occurs along the potential sliding surface. Results of such investigations provide a sound basis for realistic evaluation of the stability of the slope and the safety of the soil body. The method is applied to several examples and exact results are presented in tables.

J. J. Polivka, USA

2889. Kosterin, E. V., Some results of experiments on direct measurement of stress relaxation in clay soils (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 4, 133–136, Apr. 1957.

2890. Ushkalov, V. P., Determination of the coefficients of compression of unbroken soils thawing under pressure (in Russian), *Trudi N.-i. In-ta Osnovanii i Fundamentov* 26, 38–52, 1955; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8288.

Accelerated methods are put forward for the determination of the compression coefficient of frozen soils when thawing under loading, based on the statistical treatment of a number of experimental data obtained in laboratory conditions with thawing soils of an unbroken nature in a thermally insulated odometer 200 mm in diameter. The statistical treatment by the methods of the smallest squares and mean arithmetical values was carried out, as indicated by the author, on nearly 400 compression tests and 3000 laboratory determinations of physical characteristics. On the basis of this statistical analysis author establishes a correlation in a pressure range from 0.5 to 3 Kg/cm^2 between the relative compression and correction coefficient, taking into account the divergence of individual indicators from the mean. These correlation relations are recommended for the calculation of the coefficients of thawing and settling characterizing the compressibility of soils.

I. V. Fedorov
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2891. Shikhaliev, F. A., The influence of vibration on the viscosity of clay slips (in Azerbian), *Trudi Azerb. Industr. In-ta* no. 2, 27–36, 1955; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6870.

Measurements are described of the viscosity of clay slips by means of the SPV-5 standard viscometer set up on a vibrating foundation. The applied vibrations had a frequency between 150–1650 c/minute, with an amplitude of 0–9 mm, and were produced by means of a d-c motor. It has been found that the effect of vibration is to lower the viscosity of a clay slip—the more considerably in proportion as the initial viscosity is higher. This reduction in viscosity also depends on the duration of action of the vibrations, following an asymptotic law, and reaches a minimum after 45–75 seconds. With increasing frequency of vibration, these minimum viscosity values become smaller, tending to particular

constant values at amplitudes up to 5 mm, while at higher amplitudes the minimum is passed.

The viscosity of water, when measured by the same viscometer, is found to be independent of the presence of vibration.

B. S. Filatov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2892. Kryzhanovskaya, T. A., Interconnection of shear and pressure of rock strata when carrying out horizontal mine shaft work (in Russian), *Izv. Kievsk. Politekhn. In-ta* no. 17, 277–308, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5996.

Results are published of experimental and theoretical investigations of rock strata pressures in horizontal mine shaft work when shear is in evidence. The experimental investigation of the shear parameters was carried out on models with the help of a vibration apparatus, while for the theoretical description of the process of the shear of rock strata the system of equations for the movement of a heavy viscous and incompressible medium was utilized. Formulas are given for the determination of the vertical and horizontal shears in relation to the size of rock strata removed, the position of the point under observation, the viscosity of the medium and the mean time of the shifting. In addition, expressions are brought in for determining the speed of subsidence of the roof both in the absence of pit props and when supported with mining timbering, and also for determining the boundary value of the pit prop effect. An example is given of the calculation of pressure of the rock stratum on the pit prop.

I. V. Fedorov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Soil Mechanics: Applied

(See also Revs. 2840, 3129)

2893. Shekhter, O. Ya., The calculation of a deep rigid foundation (in Russian), *Trudi N.-i. In-ta Ossnovaniy i Fundamentov* no. 30, 45–66, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9476.

The distribution of the reactive pressures on the sole and sides of a punch occupying a rectangular cavity in an elastic semiplane with an aspect ratio of 1:2 is discussed. For a more effective method of solution of this problem, compared with those published earlier, the analytical expression for the law of distribution of the pressures is given the form of an algebraic polynomial, summated with a term representing the singularities. As a result of the calculations it is concluded that consideration of a broken outline (contour) does not essentially modify the law of distribution of the pressures over the sole.

P. I. Klubin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2894. Pasternak, P. L., The basis of a new method of calculation for rigid and flexible substructures on an elastic foundation (in Russian), *Sb. Trudi Mosk. Inzh.-Stroit. In-ta* no. 14, 116–144, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5980.

A method of calculation for beams and plates on an elastic foundation, in which the elastic properties of the soil are determined by two characteristics: the compression coefficient C_1[kg/cm^3], connecting the intensivity of the vertical resistance of the soil σ with the settling of the soil v, and the coefficient of shear C_2[kg/cm], connecting the vertical force of shear t with the derivative of settling in the longitudinal direction x,

$$\sigma = C_1 v, \qquad t = C_2 \frac{\partial v}{\partial x} \qquad [1]$$

With these assumptions, arising from the conditions of equilibrium of the elementary pillar of the foundation, the differential equation for the surface of the settling hole takes the form of:

$$\nabla^2 v(\xi, \eta) - v(\xi, \eta) = -p/C_1 \qquad [2]$$

where p is the intensity of pressure on the soil,

$$\xi = x/s, \qquad \eta = y/s, \qquad s = \sqrt{C_2/C_1}$$

When the surface of the foundation is loaded with a concentrated force N, Eq. [2] changes to

$$\frac{d^2 v}{d\xi^2} + \frac{1}{\xi}\frac{dv}{d\xi} - v = 0 \qquad [3]$$

with the solution

$$v = \frac{N}{2\pi C_2} K_0(\xi) \qquad [4]$$

(K_0 is the solution of Bessel's equation of the second type with imaginary amplitude.) In solving the problem of a round symmetrically loaded punch with radius r, the external load on the punch N attains equilibrium by means of two types of reaction $N = N_{sht} + N_l$, where N_{sht} is the sum total of the reaction in the form of evenly distributed pressure below the whole role of the punch, while N_l is the sum total of the reaction in the form of evenly distributed forces along the perimeter of the punch. The value of N_l is equal to C_1, the multiple volume of the settling hole outside the punch. In these conditions, reaction N is bound up with the settling of punch v_0 by the equation

$$N = \pi v_0 s^2 C_1 \left[\xi_0^2 + \frac{2K_1(\xi_0)\xi_0}{K_0(\xi_0)}\right] \qquad \left(\xi_0 = \frac{r}{s}\right) \qquad [5]$$

An analogous expression is obtainable for the angle of rotation of punch α_0 arising from the action of moment M. It is proposed to establish by experimental means the characteristics of C_1 and C_2 by using formulas interconnecting v_0 with N, and α_0 with M. For a rectangular rigid punch the problem is solved numerically by the method of networks. The equation for the deflection of a rectangular plate with a cylindrical rigidity D when externally loaded with a distributed load q is obtained by the substitution of the usual differential equation of deflection by the values of the reactive pressures [2]

$$\frac{s_1^4}{4}\nabla^4 w - s_2^2 \nabla^2 w + w = \frac{s_1^4}{4} q \qquad [6]$$

$$(w = Dv, \quad s_2 = s, \quad s_1 = \sqrt[4]{4D/C_1})$$

It is proposed to solve this equation with the aid of double trigonometrical rows, ordinary hyperbol-trigonometrical rows, or by the network method. In calculations for the fundamental strip with a width of $2b$ it is assumed that the strip in the transverse direction does not deform and that, consequently, the reactive pressures are of equal magnitude. The equation for the hole outside the ribbon

$$v_y = v_x \frac{K_0(\eta)}{K_0(\eta_0)} \left(\eta = \frac{y}{s_2}, \quad \eta_0 = \frac{b}{s_2}\right) \qquad [7]$$

v_x is the sagging of the strip along the axis x, coinciding with the longitudinal axis of the hole. Intensivity of the marginal reactions from the distributed forces

$$T = C_1 v_x \int_{\eta_0}^{\infty} \frac{K_0(\eta)d}{K_0(\eta_0)} \qquad [8]$$

The differential equation for the deflection of the strip with flexibility EI, with an externally distributed load q, after substituting in it the values of the reactions, determinable by Eqs. [2] and [8], is put forward in the form:

$$\frac{s_1^4}{4} w^{IV} - s_2^2 w'' + w = \frac{s_1^4}{4} q$$

$$w = EIv, \quad \frac{s_1^4}{4} = \frac{EI}{2bC_1\rho}, \quad s_2^2 = \frac{C_2}{\rho C_1} \qquad [9]$$

$$\rho = 1 + \frac{s}{2b}\int_{\eta_0}^{\infty} \frac{K_0(\eta)d\eta}{k_0(\eta_0)} \approx 1 + \frac{s}{2b}$$

The final form of Pasternak's equations for an elastic foundation agrees with the equations for foundations evolved by V. Z. Vlasov and by M. M. Filonenko-Borodich [*Ucb. Zap. MGU* 46, 1940], notwithstanding the radical differences in the mechanical models of all the three foundations. In the article of which this is an abstract, it is not explained how a soil can receive a length of force loading, transmitted by the foundation edges, the concentration of which exceeds that admissible, in the author's view, of the concentration of the distributed pressures, appearing under the edges when solving the problem in accordance with the theory of elasticity. The subject-matter of the article, with a supplement dealing with the calculations of foundations in the conditions of a plane problem, has been published before as a brochure: Pasternak, P. L., "The bases of a new method of calculations for substructures on an elastic foundation with the aid of two coefficients for the bed," Moscow, Gos. Izd. Lit. Po Str-vu i Arkhitekhture, 1954. M. I. Gorbunov-Posadov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2895. Tsytovich, N. A., Methods of calculating beams and plates on a compressed foundation (in Russian), *Sb. Tr. Mosk. Inzb.-stroit. In-ta* no. 14, 5–11, 1956; *Ref. Zh. Mekb.* no. 4, 1957, Rev. 4640.

A short survey is given of existing methods of calculating beams and plates on a compressed elastic foundation. The calculation models of the foundations are divided into 3 groups:

(1) A model based on the theory of local elastic deformations (Winkler's model).

(2) A model based on the theory of an elastic semispace (Proctor et al).

(3) Special models on an elastic base, taking into consideration compressibility tangential stresses, etc.

The nature of each model and method of calculation and the limits of application of the various theories are indicated on general lines. Problems of developing and improving the accuracy of the calculation models on compressible foundations and methods of calculation are noted. V. P. Shubin and S. M. Mulin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2896. Yaropolsky, I. V., The influence of horizontal loads on the general stability of harbour protection works (in Russian), *Trudi Leningr. In-ta Inzb. Vod. Transp.* no. 23, 21–35, 1956; *Ref. Zh. Mekb.* no. 6, 1957, Rev. 7129.

A harbor protection structure of the gravity type is examined, the sole of which is supported on an artificial random rubble foundation. The problem is investigated of the stability of the weak underlying soil strata receiving the pressure of the stone foundation under the action of vertical and horizontal forces on the structure.

The stresses in the soil are determined by the equations of the two-dimensional problem of the theory of elasticity.

The assumption is introduced that the compression stresses arising in the stone packing from the vertical pressure of the structure are distributed through the thickness of the pitching in the same manner as in the thickness of a layer formed between parallel rows of cylinders. The curve of normal stresses in the plane of the stone pitching thus obtained is assumed to represent the curve of vertical pressure of the ground by the vertical load on the structure. It is further assumed that the horizontal load acting on the structure is transmitted to the foundation soil at the foot of the stone pitching in the form of a system of shear stresses, the curve of which has the same profile as the curve of the vertical pressures. With these assumptions, two cases are examined of the loading of a semi-plane by shear and normal stresses over a restricted length, viz., (1) the case of trapezoidal distribution and (2) the case of triangular distribution.

Expressions are derived for the component stresses in relation to the maximum intensity of the shear and normal stresses acting on the semi-plane in trapezoidal and triangular form respectively. Tables facilitating the computation of these stresses are given.

The problem of the stability of the underlying subsoil stratum is solved on the basis of the known condition of limiting equilibrium by correlating the angles of deflection at individual points in the subsoil stratum with the value of the angle of internal friction of the soil. The angles of deflection are calculated for a number of characteristic points from known values of the stress components at these points, and the known internal structural pressure of a compacted soil. Lines of equal angular values are then plotted and the stability of the subsoil is analysed. A number of concrete examples of the construction of these isoclines are given, and considerations are presented on the most suitable profile for the stone pitching and the selection of the dimensions of the supporting walls of the structure, of gravity type. N. M. Figurnov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Processing of Metals and Other Materials

(See also Revs. 2878, 2977, 3185, 3187)

Book—2897. Bolz, R. W. (editor), ASME Handbook: Metals engineering—Processes, New York, McGraw-Hill Book Co., 1958, xv + 428 pp. $13.50.

This handbook contains a large amount of very informative data and should prove useful to most design and production engineering departments. Most sections are written for the user of the process but some emphasize the process for itself. Comparisons between processes as to time, cost, etc. are sometimes made on an incomplete basis and occasionally a writer appears to be "selling" the process. The sections vary rather widely as to amount and stature of the coverage; a portion, but not all, of this "spotiness" can be attributed to the nature of the topics. It is unfortunate that the first section, "Heat-Treatment of Steel", is so poorly done, and there is no section on the heat treatment of nonferrous alloys.

C. C. Osgood, USA

2898. Oakley, J., A method of assessing the die-filling characteristics of powders, *J. Inst. Metals* **87,** 26–28, 1958–59.

Limitations of the standard method of testing the flow and apparent density of metal powders are discussed, and a method is described whereby the die-filling characteristics of a wide range of powders and powder mixes may be assessed. The information derived is directly applicable to tool design.

From author's summary

2899. Johnson, W., Estimation of upperbound loads for extrusion and coining operations, Instn. Mech. Engrs., Prepr., 15 pp., 1958.

Paper presents a graphical method for close overestimates of extrusion and coining loads. Examples for various geometries, die shapes and loading methods are shown. Loads obtained by author's methods are in excess of those obtained by slip-line solutions but can be obtained by less tedious numerical procedures.

J. Frisch, USA

2900. Aramanovich, I. G., Stamp pressure on a semi-infinite elastic plane with a circular hole, *Proc. Acad. Sci. USSR, Appl. Phys. Section* **112,** 1/6, 71–75, Jan./Feb. 1957. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **112,** 1/6, 611–614, 1957 by Consultants Bureau, Inc., New York, N.Y.)

Author examines the two-dimensional problem of the elastic indentation with a flat-ended die of a semi-infinite body bounded by a plane and containing a cylindrical hole symmetrically disposed beneath the die. Method used is that of complex potentials due to Muskhelishvili. An expression is derived for the die pressure involving infinite summations. No examples are considered.

J. F. W. Bishop, Scotland

Book—2901. Lamm, M. M., The hydrodynamic theory of metal cutting and its application (in Russian), Khar'kov, In-ta 1956, 244 pp., illus., 9r. 50k.; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10874.

Author proposes to examine the process of shavings formation as the flow of a viscous liquid around the cutting tool. A hydrodynamic deduction is given for the equation of the cutting force. From the hydrodynamic point of view questions are formulated regarding the friction when metals are cut and shavings accumulated. The idea emerges for the finding of a cutting surface convenient for flowing around, and some applied problems are examined of cutting treatment (the influence of dry friction on the wear of the cutting surface, the question of tests for cutting speeds by means of face sharpening). A prominent place in the book is given to the consideration of the work of other investigators, repudiating or confirming the basic position of the hydrodynamic theory of cutting. In conclusion, a description is given of the tests of cutting tools suitable for flowing around, carried out in a number of works commencing in 1941.

G. S. Shapiro

Courtesy Referativnyi Zhurnal, USSR Translation, courtesy Ministry of Supply, England

2902. Simon, R., Drilling by vibration, ASME Petroleum-Mechanical Engng. Conf., Denver, Colo., Sept. 1958. Pap. 58-PET-21, 9 pp.

An analysis is presented of the process of vibratory drilling, based on the assumption that the load presented by vibrating on the rock to the vibration generator, a magnetostriction transducer, can be represented by a force-displacement characteristic with hysteresis. The conclusions reached are compared with experimental observation on the performance of vibratory drilling systems.

From author's summary

2903. Cadwell, D. E., Weisbecker, H. L., and McDonald, W. J., Grinding a titanium alloy with coated abrasives, ASME Semiann. Meet., Detroit, Mich., June 1958. Pap. 58-SA-44, 9 pp.

2904. Plainevaux, J. E., An explanation of chatter, markings observed in centerless grinding (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **8,** 252–262.

Author studies conditions under which a section's perturbation is able to increase and give an unstable autosupported vibration of the grinding wheel. Study applies to external centerless grinding only. Treatment of problem is mathematical and leads to a differential equation of the form

$$[D^2 + 2w_0 f D + w_0^2]^2\, y(t) = A^2 w_0^4\, y\left(t - \frac{r}{2}\right)$$

where $\frac{K}{m} = w_0^2$, $\frac{c}{m} = 2fw_0$, $f = \frac{c}{2\sqrt{(k+G)m}}$, $\frac{G}{m} = Aw_0^2$, m is the mass of the wheel, k the spring constant of the wheel spindle, G the proportionality coefficient between depth of cut and reaction force applied to the wheel, and c a damping coefficient.

Author concludes that if $A < 2f\sqrt{1-f^2}$ chattering is impossible. To achieve this requires a very rigid spindle and a large spindle damping coefficient. The relation between spindle rpm and vibrational frequency leads to unstable bands on the work having 3, 5, 7 . . . lobes.

P. Mamin, France

2905. Red'ko, S. G., Hardness of an abrasive tool, *Soviet Phys.-Tech. Phys.* **2,** 10, 2216–2221, June 1958. [Trans. from *Zh. tekh. Fiz., Akad. Nauk SSSR* **27,** 6, 2380–2386, Oct. 1957. Obtainable from Amer. Inst. Phys., Inc., New York, N.Y.]

Results of studies on the determination of hardness of an abrasive tool by means of abrasive-grain impression and scratching are given. The effect of a cooling liquid on the degree by which the hardness of the abrasive tool is decreased has been established. It is shown that the readings of an apparatus for the determination of abrasive tool hardness by a method of pit-blasting do not correspond to the force required to break the abrasive grain bond.

From author's summary

2906. Engquist, R. D., Low carbon-intermediate manganese constructional steel castings, ASME Ann. Meet., New York, N.Y., Nov.-Dec. 1958. Pap. 58-A-185, 16 pp.

The paper describes the engineering properties of low carbon-intermediate manganese cast steels. Ductility, toughness, fatigue characteristics, weldability, and machinability are discussed. Production data from many commercial heats are presented together with discussion of test data from actual castings.

From author's summary

2907. Inoue, Y., and Kobatake, Y., Effects of fillers on residual stresses in coatings (in English), *Kolloid Z.* **159,** 1, 18–24, July 1958.

2908. Phillips, R. A., Process analysis plus analog simulation yields better mill controls, *Control Engng.* **5,** 5, 113–118, May 1958.

Fracture (Including Fatigue)

(See also Revs. 2864, 3186)

2909. Steketee, J. A., On Volterra's dislocations in a semi-infinite elastic medium, *Canad. J. Phys.* **36,** 2, 192–205, Feb. 1958.

Writer deals with problem of a Volterra dislocation in order to study mathematically some geophysical effects relating to fractures in the earth. It is assumed that semi-infinite medium with free boundary surface contains a dislocation, in which displacement component shows discontinuity of the type $\Delta u = U + \Omega \times r$ (U and Ω are constant vectors). Applying Green's function method, writer presents solution consisting of six sets of Green's functions and computes displacement field generated by one of the sets, which is of the type of two double forces with moments in a plane parallel with boundary surface. Several of the results obtained are believed to be of geophysical interest, but discussion of their application is contained in a later paper [J. A. Steketee, *Canad. J. Phys.* **36,** 9, 1168–1198, Sept. 1958].

K. Kasahara, Japan

2910. Balavadze, V. K., Problem of the carrying capacity of light reinforced-concrete structures when crack formation takes place (in Russian), *Soobsbcb. Akad. Nauk Gruz. SSR* **17,** 8, 737–744, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8393.

A sufficiently reliable way for calculation of ferro-concrete components for crack formation can be obtained, in the view of the author, on the basis of considering the limiting expansibility of concrete $\epsilon_{p,np}$. On the basis of tests for light concrete, an empirical formula is proposed $\epsilon_{p,np} = 1.15R(1 + 5w)10^{-5}$, where $w = d/l$ is the relation of the diameter of the rod to the distance between the rods in the clear, R is a characteristic number. The manufacture is

recommended of compound two-layer reinforced components of heavy concrete for the compressed zone and of light concrete for the zone in tension. For calculations of these components consideration is given to the boundary condition of the reinforcement and concrete in the zones of both tension and compression.

N. I. Bezukhov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2911. Orlenko, G. P., Calculation for the carrying capacity of concrete components of rectangular section taking into consideration the prevention of crack appearance (in Russian), *Trudi Novocherkas. Politekhn. In-ta* nos. 33/37, 171–190, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8399.

Formulas are deduced for determining the carrying capacity of concrete elements of rectangular cross section, subjected to deflection, eccentric compression, axial and eccentric tension while taking into account the resistance offered by the concrete in tension. The formulas permit the introduction into the calculations of the tension elements in cases when the appearance of cracks cannot be assumed. In making calculations for the deflection, the eccentric compression with large eccentricities, the axial and eccentric tension, the following premises are accepted: the sections remain plane, the area of normal stresses in the tension zone is rectangular (with a stress value of R_p), while in the compressed zone, triangular. The calculation is carried out in separate stages. The limit of extensibility of the concrete is taken to be $\epsilon_p = 0.0001$. Conditions are indicated when it is possible to disregard the longitudinal force N or the deflection moment M in the calculations of eccentrically compressed and eccentrically tensed elements. The boundaries are analyzed in cases of small and large eccentricities of eccentric compression and the validity of the criterion $S_g \geq 0.8S_c$ is questioned. I. I. Ulitskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2912. Smith, Marie Madden, The bursting speed of a rotating plastic disc of variable thickness, Brown Univ., Div. Appl. Math. TR 35, 25 pp., Apr. 1958.

Paper presents a method for determining the bursting speed of a thin rotating disk of varying thickness made of a strain-hardening material. The method is based on Tresca's yield condition and flow law and neglects all elastic strains. Due to an assumption that the tangential stress is always greater than the radial stress, a restriction is placed on the ratio of outer to inner radii but the scope of application is still quite broad. Particular cases of linear and exponential strain-hardening are introduced and their effects studied. With linear strain-hardening, it is found that bursting of both the constant thickness and variable thickness disk can start only at the onset of plastic flow. In the exponential strain-hardening case, however, considerable plastic deformation may occur before the bursting speed of the disk is reached.

From author's summary

2913. Iosifov, M. N., Aerodynamics of blow-out of the heating surface of fire tube steam boilers (in Russian), *Trudi Leningr. In-ta Inzh. Vod. Transp.* no. 22, 144–151, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4406.

The mechanism of blow-out is discussed. It is suggested that the value of the tangential friction stress on the wall is of decisive importance. The demand is made that the conditions of blow-out should ensure a sufficiently small thickness of the laminar sublayer (which should not exceed the height of the protuberances of roughness). On this basis a system of calculation is developed which is reduced to determining the minimum necessary (critical) blow-out velocity. The effect of this on the blow-out is characterised by the relationship of the actual velocity to the critical. Examination is made of the method of increasing the blow-out effectiveness. A. A. Gukhman

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2914. Swindeman, R. W., and Douglas, D. A., The failure of structural metals subjected to strain-cycling conditions, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-198, 6 pp.

Data showing the isothermal strain-cycling capacity of three metals, Inconel, Hastelloy B, and beryllium are presented. It is noted that at frequencies of 0.5 cycle per min the data satisfied an equation of the form $N^{\alpha}\epsilon_p = K$, where N is the number of cycles to failure, ϵ_p is the plastic strain per cycle, and α and K are constants whose values depend on the material and test conditions. Data on Inconel are given to establish the effect of grain size, specimen geometry, temperature, and frequency. It is found that, at temperatures above 1300 F, grain size and frequency exert a pronounced effect on the rupture life. Fine-grained metal survives more cycles before failure than coarse-grained material. Long time cycles shorten the number of cycles to failure when the strain per cycle is low. Thermal-strain-cycling data for Inconel are compared to strain-cycling data at the same mean temperature. Good correlation is found to exist between the two types of tests.

From authors' summary

2915. Ouchida, H., Fatigue strength of steel specimens with artificial cracks, *Bull. JSME* **1,** 3, 233–239, Aug. 1958.

In this paper are described fatigue tests carried out to determine the fatigue strength of artificially cracked specimens made from mild steel, 0.45% C steel, 13Cr steel and Ni-Cr steel under rotary bending. Axially cracked specimens gave considerably lower fatigue strength-reduction factors, compared with those of partial circumferentially cracked or round cracked specimens, which have the value 2.4–3.4 when crack length or depth is nearly equal to 2 mm.

The strength-reduction factor of a specimen with semicircular groove containing axial or circumferential cracks is equal to the product of the strength-reduction factor of the notch itself and that of the crack itself. And then the reduction factor depending on the diameter of artificially cracked specimens is nearly equal to 1.1.

The shot-peening process gave an increased fatigue strength of 18% for mild steel and 30% for Ni-Cr steel specimens with artificial cracks. From author's summary

2916. Nakamura, H., Amakasu, T., and Ueda, S., Fatigue strength of induction-hardened test-piece with crack, *Bull. JSME* **1,** 3, 227–232, Aug. 1958.

One of the reasons why the fatigue limit rises remarkably in the notched specimen of steel which is induction-hardened is that the cracks produced do not propagate any further.

In this connection, some experiments on rotary bending were made with the specimens of a plain carbon steel with 0.18%C, some of which are ordinary plain specimens and others have some crack; both were tested for two cases, i.e., non-heat-treated and induction-hardened.

The results are as follows:

	fatigue limit
(1) without any heat treatment	
a) ordinary plain specimens	20 kg/mm²
b) specimens with some crack	10 kg/mm²
(2) induction-hardened	
a) ordinary plain specimens	54 kg/mm²
b) specimens with some crack	48 kg/mm²

The reduction rate of the crack is apparently less in the latter than in the former, which is less hardened.

To explain this seemingly contradictory fact, Prof. Ishibashi's opinion has been applied, namely that the tip of crack must be subjected only to tension stress during rotating bending tests.

From authors' summary

2917. Nordby, G. M., Fatigue of concrete—a review of research, *J. Amer. Concr. Inst.* **30,** 2, 191-219, Aug. 1958.

2918. Owaku, S., and Morikawa, S., Micro-structural observation on fatigue fracture of metals, *Bull. JSME* **1,** 2, 129-133, June 1958.

Authors have microstructurally studied why the fatigue fracture of metals appears smooth and shelly; white or black. The study has revealed that fatigue fracture, initially rough, becomes smooth under repeated stress; the metal dust produced is sintered and, in the case of high-carbon steel, quench-hardened under friction heat into a very hard material.

In this process, if air enters into the crack the color of fracture surface will turn to black owing to the influence of friction heat; otherwise it will be white. From authors' summary

2919. Findley, W. N., A theory for the effect of mean stress on fatigue of metals under combined torsion and axial load or bending, Brown Univ., Engng. Materials Res. Lab., Div. Engng., TR 6, 22 pp. + 4 figs., Mar. 1958.

The concept that alternating shear stress is the primary cause of fatigue with the normal stress on the critical shear plane as an influencing factor has been developed for the case of mean (or static) stresses superimposed on combinations of torsion and axial load or bending. The influence of the maximum stress of the cycle of stress on the allowable alternating stress for a given number of cycles and on the orientation of the critical shear plane is explored. The predictions of the theory are consistent with the known trends of fatigue data both for ductile metals and cast irons. The theory explains the fact that the influence of mean stress is small for torsion and stronger for bending of ductile metals but strong for both torsion and bending of cast irons. As far as is known this is the first rational theory for the influence of mean stress. From author's summary

2920. Stott, T. C. F., Fatigue testing of vehicle components, Instn. Mech. Engrs. Auto. Div., Prepr., 10 pp., 1958.

2921. Nelsson, L. E., Influence of surface processing upon the fatigue properties of machined materials (in Swedish), Instn. Hallfasthetslara, Kungl. Tekn. Hogskolan, Stockholm, Publication no. 120, 1957.

Critical survey of the literature on the effect of polishing, grinding, turning, surface rolling and shot-peening on fatigue properties. It is concluded that the best surface treatments are those producing cold working and residual stresses in the material.

F. De Kazinczy, USA

2922. Kotzegubov, V. P., Some problems of the endurance of pine timber in compression along the grain (in Russian), Researches on the strength and deformation of timber, Moscow, Gos. Izd.-vo Lit. po Str-vu i Arkhitekture, 1956, 127-140; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9768.

Results are presented of an experimental investigation of the yield point in compression along the grain on small samples of clear timber, taken from different parts of a log which had been in use for 154 years. It was found that the strength of the wood which had remained under compression (in the center of the log) was less than that of the wood which had not been under compression (toward the ends of the log) by about 2-12%. The reduction in strength is to be explained by the long continuance under load.

V. N. Antipov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2923. Blatherwick, A. A., and Lazan, B. J., Effect of changing cyclic modulus on bending fatigue strength, WADC TR 56-127 (ASTIA AD 110492), 67 pp. + 11 tables + 53 figs., Oct. 1956.

After reviewing literature of size and shape effects in fatigue tests, authors develop theory of fatigue test for material showing idealized stress-strain behavior. Assumed stress-strain loops are formed of linear segments, and show work-hardening or softening depending on number of cycles and amplitude of present cycle. Reviewer believes model is acceptable for tests at constant strain amplitude but not under other conditions where position of plastic boundary depends on number of cycles. Analysis is carried out for direct axial loading and for bending tests under conditions (1) constant strain, (2) constant maximum stress, (3) constant bending moment for variety of cross sections.

Experimental verification is obtained with a strain-softening mild steel and with an aluminum alloy which, under conditions of test, was nonhardening. Observations were made on the formation and growth of fatigue cracks.

F. R. N. Nabarro, South Africa

Material Test Techniques

(See Rev. 2930)

Properties of Engineering Materials

(See also Revs. 2813, 2814, 2815, 2825, 2832, 2833, 2903, 2905, 2906, 2907, 2914, 2917, 2919, 2922, 2923, 2955, 2974, 2975, 2977, 3185, 3187)

Book—2924. Mott, N. F., and Jones, H., The theory of the properties of metals and alloys, 2nd. ed., New York, Dover Publications, Inc., 1958, x + 326 pp. $1.85 (Paperbound)

2925. Shinn, D. A., Selected properties of structural materials at elevated temperatures, *AGARD Rep.* 104, 16 pp. + 24 figs., Apr. 1957.

This report presents a review of some of the information which must be available to permit detail design of elevated-temperature aircraft and missile structures. A reading of the references will give the impression that a considerable amount of data has been obtained. Such an impression is correct. However, the demand for such data is tremendous and, in actuality, the surface has hardly been scratched. One proposal in the U.S.A. to help satisfy the demand would have set up perhaps five to ten facilities with semi-automatic equipment which could test perhaps one hundred specimens simultaneously at each facility. A program of stress, temperature, and time based on the flight path of an actual proposed aircraft would be fed into the equipment and cause simulation of service history in the test specimens. This plan would be followed for each proposed aircraft. A comprehensive program of this type would be expected to permit calculation of residual strength in a structural element of any aircraft at any time in its history or manufacture. Needless to say, because of the magnitude of such a plan, it has not yet been initiated. However, many capable people are giving serious thought to this and similar plans.

If it is assumed that no spectacular increases in propulsion efficiency occur, it is going to be quite a struggle to keep airframe structures light enough to fly at high Mach numbers. Design criteria of the type presented in this report will help in some small way but considerably more must be done.

From author's summary

2926. Klier, E. P., Feola, N., Viggiano, A., and Weiss, V., The properties of constructional metals as a function of temperature and strain rate in torsion, WADC TR 56-216 (AD 110 559), xiv + 37 pp. + 125 figs. + 30 tabs., Nov. 1956.

Seven structural materials were tested in torsion at four strain rates and various temperatures and the torque-twist relationships determined for the three lowest strain rates. Both solid and tubular specimens were tested. The strain rates tested were 10^{-5}, 10^{-3}, 10^{-1}, and 10 in./in./sec; the temperatures investigated ranged from room temperature to 1200 F; and the materials investigated were 4340 steel in two hardness grades, 321 stainless steel, 7075-T6 aluminum, AZ-31 magnesium, RC-70 and C-130-AM titanium alloys. Data are shown in the effects of strain rate and temperature on the modulus of rupture, yield strength, proportional limit, modulus of rigidity, fracture shear strain, and the energy absorption of the various materials.

E. E. Sechler, USA

2927. Sakurai, T., Kawasaki, T., and Kita, Y., Study on the changes of the properties of steel caused by low-temperature-quenching (4th report). Improvement of notch fatigue strength, *Bull. JSME* **1,** 2, 114-118, June 1958.

Low-temperature quenching (L. T. Q.) is greatly effective on improving the mechanical properties, especially the fatigue strength, of steel.

The effect of the L. T. Q. on the increase of the fatigue strength is more remarkable in specimens with notch than in plain ones. The reason for this is as follows:

(a) The strengthening of the ferrite by strain-aging during the repeated loading must be more remarkable owing to the sharp concentrated stress at the root of notch which accelerates the strain-aging.

(b) Before the formation of fatigue crack at the root of notch, there appears a region which resists the formation of fatigue cracks. In the low-temperature-quenched specimen, this region is not only expanded inward more and more by repeated loading but also strengthened.

(c) When a fatigue crack is once formed, the resistance against its propagation is greater in notched specimens than in plain ones.

From authors' summary

2928. Crancher, D. W., Materials for superheater tubes and supports, *Trans. Inst. Mar. Engrs.* **70,** 3, 77-103, Mar. 1958.

The trend to higher steam temperatures and the deterioration in the quality of fuel oil has made the problem of the choice of suitable materials for superheater tubes and supports one of the most pressing boiler design problems. Six tube steels have been developed in this country covering, as far as creep strength is concerned, a range of allowable metal temperatures up to 1230 deg. F. The necessary properties of such steels are: creep and corrosion resistance in both steam and flue-gas atmospheres; adequate mechanical strength at room temperature; ease of welding; adequate strength of welded joints; and availability. These properties are discussed in the paper in relation to the available materials.

The question of steam and flue-gas corrosion is discussed. The most important factor is attack by molten fuel ash; no known commercial metal is immune from this. Closely associated with this is the problem of ash fouling of tube banks.

The choice of materials for supports is complicated by the question of ash attack. In the absence of such attack, heat-resisting steels are available with adequate strength up to 1800 deg. F or so. Methods of combating ash attack and fouling are discussed and it is suggested that the most promising solution is to treat the fuel; an appendix is added describing two methods of doing this.

From author's summary

2929. Jahnke, W. E., and Kuenzi, E. W., Performance of brazed stainless steel sandwich at high temperatures, Part III, WADC TR 55-417, 10 pp. + 1 table + 11 figs., Jan. 1958.

Report presents results of tests to investigate structural performance of stainless steel sandwich comprised of facings brazed to honeycomb cores. Performance was determined at 75, 800, 1,000, and 1,200 F after short-time exposure to test temperatures. Included in this report are comparisons between facing stresses actually developed in test specimens and stresses computed theoretically for sandwich that fails either by dimpling of facings into the core cells or by buckling when subjected to edgewise compression.

From authors' summary

2930. Fusner, G. R., and Newhouse, D. L., M-252 alloy for heavy-duty gas-turbine buckets, *Trans. ASME* **81A** (*J. Engng. Power*) 2, 161-176, Apr. 1959.

In order to apply safely a turbine-bucket alloy which has been successful in short-life high-temperature aircraft gas turbines to long-life heavy-duty gas turbines, it was necessary to make many laboratory tests. These included tensile, rupture, creep, fatigue, damping, oxidation, and corrosion tests. Many of these tests were made on specimens which had been aged for 5000 and 10,000 hr. Rupture data were obtained to 15,000 hr. Operating experience has confirmed laboratory tests and now M-252 is destined to become a standard bucket material for heavy-duty gas turbines.

From authors' summary

2931. Geil, G. W., and Carwile, N. L., Effect of strain-temperature history on the tensile behavior of titanium and a titanium alloy, *J. Res., Nat. Bur. Stands.* **61,** 3, 173-186, Sept. 1958.

This study was made to determine the effect of prestraining specimens in tension under uniaxial and multiaxial stresses at a selected temperature on their tensile behavior at a different temperature. Unnotched and notched cylindrical specimens of initially annealed, commercially pure titanium and initially annealed 4-percent-aluminum, 4-percent-manganese, titanium alloy were extended at selected temperatures to various true strains and then extended to fracture at another temperature. The ductility retained by the prestrained specimens decreased with increase in the prestrain, whereas the strength indices generally were nearly independent of the amount of the prestraining. However, strength indices obtained on some of the deep-notched specimens of the alloy at −196C were decreased by prestraining at +25C as a direct result of the very low retained ductility of the prestrained specimens.

From authors' summary

2932. Hoffman, G. A., Whiskers, *J. Metals* **10,** 9, 591-595, Sept. 1958.

Tiny perfect crystal filaments, with strength approaching the theoretical limit of atomic cohesion, may be the building-blocks of the astronauts.

From author's summary

2933. Kestin, J., and Moszynski, J. M., An experimental investigation of the internal friction of thin platinum alloy wires at low frequencies, AFOSR TN 58-752 (Brown Univ., Div. Engng. Tech. Rep. 11; ASTIA AD 201 516), 18 pp. + 4 tables + 7 figs., July 1958.

Report describes the design of a special high-vacuum calibration unit for suspension wires used in viscometry. Results concerning the internal damping of platinum-tungsten wires and the temperature effect on their elastic properties are given.

From authors' summary

2934. Hansen, T. C., Creep of concrete—a discussion of some fundamental problems (in English), *Swed. Cem. Concr. Res. Inst., Roy. Inst. Technol. Stockholm Bull.* 33, 48 pp., 1958.

In Chap. 1 author discusses the measurement of creep in drying concrete. Creep data are often corrected for shrinkage by measuring the shrinkage of an unloaded specimen. Limitations of this approach are pointed out. In Chap. 2 the relationship between creep and shrinkage is discussed. Data are presented to confirm the hypothesis that "it is not the dry condition itself but the drying out that is responsible for the increased creep of drying con-

crete, as compared with the creep of wet or dry concrete." Third chapter introduces subject of basic creep (i.e., creep in the absence of moisture diffusion) which author claims should be predicable from volumetrical or rheological considerations.

Fourth chapter discusses elastic, plastic and viscoelastic properties of concrete. Two interesting topics considered are relation of plasticity to microcrack formation and prediction of elastic modulus from the moduli of aggregate and mortar. Chapter 5 relates creep to the composition of the concrete. A formula is derived which connects creep to the volume concentration of cement paste and the water-cement ratio. Finally, Chap. 6 gives a brief discussion of mechanical models.

Reviewer finds article to be an excellent general summary of the mechanical aspects of creep in concrete, together with new data and theories. I. Finnie, USA

2935. Facaoaru, and Stanculaescu, G., Influence of shrinkage on the variation of the dynamic modulus of elasticity of concrete with rapid setting cement (in Roumanian), *Rev. Constr. Mat. Constr.* **10**, 1, 15–19, 1958.

Referring to previous research and experiments by Dutron, Lucas, L'Hermite, Shank, Thomas, Whitney, Goodell and theoretical investigations by Freyssinet, L'Hermite, Seikin and Pickett, tests performed by authors in Roumanian Research Institute are thoroughly described and discussed. Various relationships between the relative humidity of concrete and resonant frequency, and the effect of relative humidity (40 and 100%) upon ultimate strength and modulus of elasticity during the period from 1 to 28 days are demonstrated in diagrams and tables. Of special interest are results concerning properties and preservation of concrete with rapid-setting cements. Further references are made to V. Nicolau and sonic testing methods described by A. Hutter in *Bauplanung und Bautechnik* Sept. 1955.

J. J. Polivka, USA

2936. Bueche, F., Tensile strength of plastics: Effects of flaws and chain relaxation, *J. Appl. Phys.* **29**, 8, 1231–1234, Aug. 1958.

Author presents a theory for tensile strength of amorphous plastics. It extends a previous theory so as to include effects of imperfections and chain relaxations. Result obtained shows that the time t_c, taken for a plastic to break under constant stress F, is given by

$$F = C - B \ln(t_c),$$

where B and C are molecular constants whose experimental values are shown to be consistent with their molecular interpretation. Extended theory shows that the effect of chain relaxation is the major time-dependent factor as far as strength is concerned.

From author's summary by Å. Isaksson, Sweden

Symposium on Twelfth annual review of materials of construction, *Indust. Engng. Chem.* **50**, 9 (Part II), 1426–1498, Sept. 1958.

2937. Horst, R. L., Aluminum alloys, 1427–1432.

2938. Lennon, J. W., Ceramics, 1433–1437.

2939. Garvey, B. S., Jr., Elastomers, 1438–1443.

2940. Grove, C. S., Jr., Casey, R. S., and Vodonik, J. L., Fibers, 1444–1448.

2941. Mullarkey, E. J., Lead and its alloys, 1449–1454.

2942. Sherwood, E. M., Less common metals, 1455–1459.

2943. Marron, A. J., Nickel, including high-nickel alloys, 1460–1469.

2944. Seymour, R. B., Plastics, 1470–1478.

2945. Scofield, F., Protective coatings, 1479–1481.

2946. Luce, W. A., and Peacock, J. H., Stainless steels including other ferrous alloys, 1482–1488.

2947. MacIntosh, R. M., Tin and its alloys, 1489–1492.

2948. Bomberger, H. B., Titanium, 1493–1495.

2949. Stamm, A. J., and Baechler, R. H., Wood, 1496–1498.

Structures: Simple

(See also Revs. 2795, 2839, 2842, 2854, 2857, 2861, 2862, 2863, 2864, 2880, 2895, 2911, 2935)

Book—2950. Beedle, L. S., Plastic design of steel frames, New York, John Wiley & Sons, Inc., 1958, xiii + 406 pp. $13.

The content and level of this book are fairly stated in the first two sentences of the author's preface: "This book presents the principles and methods that are the basis of plastic design and shows how they may be used in the solution of practical building frame design problems. It was written for students of structural engineering—those in colleges and universities on the one hand, and those in engineering practice on the other."

Book is divided into 9 chapters plus 2 appendices. Chapter 1 states the case for plastic design and its relation to elastic design. Chapters 2 and 3 describe the basic theory of plastic analysis for beams and simple frames. Chapter 4, Secondary design problems, discusses axial and shear force, local and lateral buckling, column stability, brittle fracture, and repeated loadings. None of these topics are considered part of plastic design, but their presence may render plastic design inappropriate. Thus the emphasis is on how to determine when such influences may reasonably be neglected, and, in some cases, what simple modifications of plastic theory may be made to account for their presence. Chapter 5 contains a detailed treatment of the design of straight corner, haunched, and interior beam-column connections. Chapter 6 discusses methods of estimating deflections under ultimate or working loads.

The last three chapters contain detailed instructions for design of continuous beams and frames. Typical examples are considered in great detail by means of extended work sheets and textual comments. The appendices are entitled "Spacing of lateral braces" and "Plastic modulus table."

This book is one of several with similar titles which have appeared in recent years (e.g., Baker, Horne, and Heyman, "The steel skeleton"; Heyman, "Plastic design of portal frames"; Neal, "The plastic methods of structural analysis"; Hodge, "Plastic analysis of structures"). Compared to these books, it is very definitely directed to the practical engineer who may be expected to put the techniques described to direct immediate use. Mathematics is avoided to an incredible extent (the only integral in the book occurs in a footnote). The theorems of limit analysis are stated, but not proved. Only two (statical method and mechanism method) of the various techniques for exploiting plastic analysis are described. Repeated loadings are touched only briefly. Curved beams or more complex structures are not considered at all.

On the other hand, the work sheets in the last three chapters are so clear and detailed that they can probably be used without necessarily knowing the underlying theory. The elementary treatment given to secondary design problems is most valuable from a practical viewpoint. The discussion of connections, both as a detail and as part of a composite structure, is a unique contribution of the present book.

In summary, the leader, whether teacher or supervisor, who wants to train people to quickly design elementary structures by plastic methods might well refer them to this book for the "how"

of plastic design. However, the leader himself should probably also study one or more of the other books mentioned in order to understand more of the "why" of plastic design.

P. G. Hodge, Jr., USA

2951. Vinogradov, A. I., Problems of the design of structures of minimum weight (in Russian), *Trudi Khar'kovsk. In-ta Inzh. Zh.-d. Transp.* no. 25, 175 pp. + illus., 1955; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9502.

The book deals with a method of predetermined stresses for the calculation of statically-indeterminate beams, trusses and arches, of variable cross section. The case of a single load and that of multiple loading by different forces, are examined, the assumption being made in the latter case that these loads are applied in any arbitrary combination. Some results of these investigations have already been published [*Ref. Zh. Mekh.* 1955, Revs. 3921, 3922]. The author introduces sign-changing functions in his method of calculation; which is one of the means for ensuring that the result of the analysis furnishes essentially positive values for the moments of inertia and the cross-sectional areas.

The first chapter gives definitions for the sign-changing functions, indicates various operations to be performed on these functions, and describes their properties.

The second chapter discusses the conception of the multiplicity of possible constructions with a given outline of the axes. Continuity equations are developed for the strains in statically-indeterminate beams, in a form characteristic for the method of stresses; and symbolic notation is determined. The conditions of solvability of the said equations are examined. Examples of solution are given for beams of equivalent strength as well as for trusses, without allowance for the normal forces. The problem is discussed of the truss of minimum weight, and the corresponding equations are derived for the framework of least volume, in the case of a bending load. The conditions are established in which these systems are compatible with the equations of continuity of deformation (strain).

In the third chapter, the equations of continuous strain are derived for the case of simultaneous bending and compression, the form characteristic for the method of stresses; the difficulty of their solution is remarked on. For the bending case, an analysis is made of the possibility of a solution, the multiplicity and singularity of the solutions, as depending on the ratio between the number of points in which the bending moment changes sign, and the given number of redundant joints. Then, with certain assumptions, an investigation is made of the case of simultaneous bending and compression. The proposition already well-known in the theory of statically-indeterminate trusses, that the possible limiting values of the internal forces (the limits of the region of existence of redundant unknowns, and all forces) are statically-determinate, is proved for systems loaded in bending. Considering, on page 56, the case of a beam with constrained ends and two hinged-joints in the span, the author postulates that if the reciprocal angles of rotation in the hinges of this beam are equal to zero, i.e. the elastic line is smooth, the beam constitutes a statically-indeterminate system. On page 28, the author considers the identical beam as a system occupying an indeterminate position between a statically-determinate and a statically indeterminate system. In the author's opinion, such a beam may be absolutely of equal strength and, simultaneously, statically-indeterminate; with the original number of redundant joints.

In the fourth chapter, the equations of minimum volume are derived for the case of simultaneous bending and compression. An example of a solution of these equations for a rigid arch is used to demonstrate that acceptable solutions exist only when the number of points in which the bending moment changes sign is not less than the given number of redundant joints. Then, the equations of minimum volume for the case of simultaneous bending and compression are set up, for multiple loading by different loads. These equations, and some others, are derived on the basis of forming analytical combinations of the individual loads on the axial bending moment, which, as the author mentions, is permissible for loads principally acting on the structure in bending. Subsequently, however, they are applied also to arches struck on the curve of pressures due to the constant and half of the live load, for any ratio between the dead and live loads—to arches stressed principally in compression. The most favourable influencing lines are considered. Representing the volume of the beam as a function of the redundant unknown, in the presence of a constant load, the author demonstrates on an example that the curve representing this function has a minimum at one point only. A similar property is demonstrated for the general case. The properties of systems of least volume are investigated, both for the case of calculation for a single load, and for the case of calculation for a number of loads.

The fifth chapter describes methods of solving the equations of least volume for symmetrically, statically indeterminate beams and arch girders. An example is given of the solution of the problem of least volume for a doubly-hinged arch of uniform strength, with the axis plotted along the pressure curve of the combined constant and half the live load.

In the sixth chapter, the calculation of uniform strength arches by the equations of least volume is discussed in detail on the example of a rigid arch with the axis plotted on the curve of pressure due to the combined constant and half the live load. The theoretical volume of the most favourable arch of unequal strength, calculated by the usual method, is found to be 18–22% greater than the theoretical volume of the equal-strength arch.

The seventh and final chapter contains tables facilitating the selection of suitable arch sections, with an example of the selection of sections for an equal-strength, reinforced-concrete arch. Making some assumptions, the volume of the unequal strength arch calculated by the usual method is found to be 12% greater than the volume of the equal-strength arch.

K. M. Khuberyan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2952. Mihai, I. P., Determination of maximum amount of reinforcing steel in prestressed concrete beams (in Roumanian), *Rev. Constr. Mat. Constr.* **10**, 1, 19–24, 1958.

Referring to previous study by Freifeld, Ratz, Berdicevski and Mihailov, criteria are presented regarding fissures and ruptures under various amounts of reinforcing in the compression and tension zones. Theoretical derivations are compared with test results. Further references are made to research and publications by Laupa, Siess, Newmark, Elstner, Hognestad, Janney, McHenry and Chambaud.

J. J. Polivka, USA

2953. Tassi, G., The possibility of anchorage on finite length in pretensioned prestressed concrete (in English), Extracts from the Scientific works of Chair no. II of Bridge Construction, Tech. Univ., Budapest, 1957; 41–50.

The paper states that there is to be found a mathematical relation (called bond-function) between the bond-force and the relative displacement of the originally common cross sections which results in a complete transmission of the tension force on a finite length in pretensioned prestressed concrete beams. The experimental relations practically satisfy the criterion of the bond function resulting in a finite anchoring-length. Author describes his experiment, verifying the possibility of anchoring on finite length.

From author's summary

2954. Mihai, I. P., Prestressing by the autoclave method (in Roumanian), *Rev. Constr. Mat. Constr.* **10**, 7, 389–392, July 1958.

Author describes experiments performed in Bulgaria by D. Vacev, H. Gresenljev, St. Stamenov and St. Kolev at the Institute

of Structural Research in Sophia. Advantages of this method are emphasized as greater resistance against fissuring, increase of strength, possibility of using steel wires of lower strength (e.g. 2–3-mm wires having ultimate strength of 100,000 psi), greater economy (25–40% reduction of cement). J. J. Polivka, USA

2955. Trbojevic, B., Prestressed and precast floors (in Serbian), *Naše Gradevinarstvo* **12,** 7, 159–163, July 1958.

Advantages of prefabrication of structural elements—slabs, joists, beams, columns, etc.—are described with references to typical examples and methods used in England, France, Germany and other countries, such as Hoyer-Wettstein, Bison, Sigma, Stahl, Costa magua, stup-Inov, etc. Also combination of concrete with other materials, like ceramic tiles, is described.

J. J. Polivka, USA

2956. Wood, R. H., The stability of tall buildings, *Proc. Instn. Civ. Engrs.* **11,** 69–102, Sept. 1958.

The benefits arising from plasticity in structures are well established, but it is not so well known that the beneficial effects may be curtailed in multi-storey frames because of simultaneous deterioration of elastic stability. This study of frame instability is perhaps the most perplexing and intriguing research subject of the moment in frame design, and an attempt is here made to clarify what is involved. Part of the present difficulty arises from a neglect in the past to study the stiffening effects of the cladding of tall buildings.

Within this setting an account of the work of the Building Research Station is given, and in relating this work to that of other research schools it is convenient to present the subject in the form of a brief historical account of the development of research. The emphasis throughout is on the necessity of producing rapid design methods. The great distinction between "no-sway" designs and designs involving side-sway is brought out, together with the effects which frame instability and composite action have on this issue. In spite of the tremendous numerical work obviously involved a mathematical treatise is purposely avoided.

It appears that, whereas it is imperative to make provisions for probable loss of carrying capacity of frames due to instability, the general behavior of practical frames favors "collapse" design, particularly if some simple, and in the meantime modest, contribution from composite action can be devised.

From author's summary

2957. Home, M. R., Plastic design of a four-storey steel frame. Part I, *Engineer, Lond.* **206,** 5350, 204–207, Aug. 1958.

2958. Home, M. R., Plastic design of a four-storey steel frame. Part II, *Engineer, Lond.* **206,** 5351, 244–245, Aug. 1958.

2959. Miljenko, B., Method of column analogy in rectangular frames with one axis of symmetry (in Serbian), *Naše Gradevinarstvo* **11,** 7, 200–202, July 1957.

Method based on principles of ellipse of elasticity (introduced in last century by the Swiss engineers Culmann and Ritter) is discussed and applied to rectangular frames restrained at supports and with continuity at supporting corners, both structural types having vertical axis of symmetry. Theoretical analysis is thoroughly explained in two numerical examples pertaining to both structural types, subject simultaneously to vertical and horizontal loading. One support is released to make the structure statically determinate, and the redundant forces (bending moments) are found by equalling elastic deformations (rotations and displacements) of the statically determinate system and those caused by redundant forces. Reference is made to Hardy Cross and to the book "Calculo de estructura reticulare" by Carlos Fernades Casato, 3rd ed., Editorial Dorsat, Madrid, 1944.

J. J. Polivka, USA

2960. Lightfoot, E., A moment-distribution method for Vierendeel bents and girders with inclined chords, *Proc. Instn. Civ. Engrs.* **10,** 321–352, July 1958.

Presented method has been developed from theoretical contributions of several engineers, and author mentions especially L. C. Maugh (panel method), A. Bolton ("no-shear" method), R. H. Wood ("degree of fixity" procedure) and others. Three structures are analyzed by author's extended method of moment distribution. The method can be used for all effects which need to be considered in design, including influence lines. Classical methods of analyzing Vierendeel bents and trusses are reviewed (Baes, Magnel, Gough, Bateman, Dana Young, Marneff, Robert, Beaufoy, Diwan). It is also explained how the original moment-distribution method of Hardy Cross has been previously adapted for such open-web girders, using two procedures for determining the effects of side-sway, as described more thoroughly by Maugh and Grinter and used by J. L. Matheson, E. S. Needham and L. A. Beaufoy.

In reviewer's opinion, all moment-distribution methods have the disadvantage, especially in more complicated statically indeterminate structures such as Vierendeel trusses, that the analysis has to be carried out for each individual type of loading from the very beginning and the accuracy of the results can be checked only after the analysis is completed. Author doesn't mention methods which can be applied for various loadings with greater simplicity (e.g. method of the ellipse of elasticity).

J. J. Polivka, USA

2961. Strasser, G., Optimization of multiweb beams under combined bending and torsional loading, *J. Aero/Space Sci.* **25,** 8, p. 529 (Readers' Forum), Aug. 1958.

2962. Kapanyan, L. K., Bending of some types of hollow girder bars (in Russian), *Izv. Akad. Nauk ArmSSR, Ser. Fiz.-matem., Estestv. i Tekhn. Nauk,* **9,** 3, 33–43, 1956; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10778.

A solution is given for the problem of the flexure of a girder-type prismatic rod with a circular cross section, weakened by a regular curvilinear, symmetrically placed quadrangular cut, taken to replace a square sufficiently akin to it. The girder is fastened at one end, while a concentrated force is applied to the free end along the diagonal and the smallest axis of the square. The section is reflected approximately onto the annular ring at boundaries of the region which are disposed sufficiently far away; the holomorphous function in the ring is looked for in the form of a Lorentz series, the determination of the coefficients thereof merging, on the basis of the boundary conditions, with the solution of a finite system of algebraical equations (10 equations). The solution obtained is used to determine the tangential stresses. The study is furnished with a numerical example, where the tangential stresses are computed for points on the neutral axis of the section. The author indicates erroneously that the solution of the given problem by D. I. Sherman's method is cited in the work of Yu. A. Amenzade, [*R. Zh. Mekh.* 1956, Rev. 5346] when actually it was referred to in another of his works [*R. Zh. Mekh.* 1957, Rev. 3394].

Yu. A. Amenzade

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2963. Stevens, L. K., Moment curvature relationships for axially loaded members, *Civ. Engng., Lond.* **53,** 626, 904–906, Aug. 1958.

Paper describes an inverse method particularly suited to H sections bent about the minor axis.

From author's summary

2964. Martemyanov, A. I., The strength of cohesion of an anti-seismic (anti-earthquake) course with a masonry wall (in Russian),

Izv. Akad. Nauk UzSSR no. 8, 69-77, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9635.

Results are communicated of experiments on the evaluation of the tangential (shearing) cohesion in different cement and mortar mixes; suggestions are made for improving the cohesion between the antiseismic course and the masonry.

Author's summary

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2965. Medvedev, S. V., Relationship of seismic disturbances to the periods of natural vibrations of structures (in Russian), *Trudi Geofiz. In-ta Akad. Nauk SSSR* no. 36 (163), 80-113, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8391.

Structures: Composite

(See Revs. 2785, 2849, 2869)

Machine Elements and Machine Design

(See also Revs. 2897, 3189)

Book—2966. Assmus, F., Gear-movements in technology (including watch movements) [Technische Laufwerke Einschliesslich Uhren], Berlin, Springer-Verlag, 1958, vii + 279 pp. DM 36.

Book provides extensive design information, both theoretical and practical, on the subject of mechanical movements of the type used in precision instruments such as watches, camera shutters, music boxes and time fuzes. The chapter headings indicate the clearcut categories into which the subject is divided:

The mechanism (chap. 1); Gearing (chap. 2); Friction, energy loss, and bearings (chap. 3); the drive and the realization of the driving torque (chap. 4); Indication (chap. 5); Control (chap 6); Watch chimes (chap. 7).

Books of this type directed at the theoretical designer as well as the practical mechanic are rare in English technical literature. The book, therefore, fills a definite gap in this field—and fills it competently. Isolated portions, such as gear design, can be found ably, perhaps better, described in other English texts, but there is a wealth of specialized design information not readily found elsewhere.

Thus gear trains are well covered (except for the Brocot table and continued fractions which are treated somewhat too briefly). Of particular value is: the detailed treatment of cycloidal gear teeth, a subject which is generally omitted; practical design information on bearing construction; energy storage devices; indication and recording mechanisms; the theory of escapements (especially of untuned escapements which the reviewer has not seen treated in book form previously); and the design of escape wheels.

Book is well and clearly written and the printing and illustrations are excellent. It is recommended highly as a competently written text for students and designers in the instrument and precision mechanics field. F. Freudenstein, USA

2967. Harris, S. L., Dynamic loads on the teeth of spur gears, *Proc. Instn. Mech. Engrs.* **172,** 2, 87-112, 1958.

See AMR **11** (1958), Rev. 3905.

2968. Mangeron, D., and Dragan, C., A new analytic-graphical approach to the problem of the distribution of accelerations of any order (in German), *Bull. Inst. Polytech. Iasi* **3,** 3/4, 161-174, 1957.

By using the concept of reduced acceleration of n order for the points of a rigid solid in parallel plane motion, defined as the acceleration ratio of n order and a certain function $A_n(t)$ given by the recurrence relations which include the derivatives with respect to time of the rotation angle θ, paper establishes a series of properties leading to the solving of the problem of the distribution of accelerations of any order for plane mechanisms. Analytic-graphical applications are included for a sequence of most characteristic Assur groups. Method of reduced accelerations is interesting both for the theory of mechanisms and machines and for the differential geometry of plane curves.

Cr. Pelecudi, Roumania

2969. Hopp, Yu. A., The analysis of the constrained oscillations of chain systems with friction considered (in Russian), Oscillations in turbine machinery, Moscow, Akad. Nauk SSSR, 1956, 191-205; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 8634.

A method is put forward for determining the amplitudes of constrained oscillation of a chain system (considering frictional forces proportional to the first order of the relative velocities of the masses), founded on the direct calculation of the determinants whereby the solution is expressed. This calculation can be substantially simplified if use is made of the recurrent relationships suggested in the paper, which enable the determinant to be calculated to be reduced to one of lower order.

The method is applicable not only to simple chain systems (consecutive linkage of the masses), but also to branching systems. The analytical expressions can be simplified if the frictional forces are approximated (retaining only terms containing the first power of the parameter characterizing the friction). An estimate is given of the number of operations required to complete the analysis by the different calculation methods. This comparison shows the great economy in the number of operations required when using the method of analysis suggested in the present paper.

A. I. Lur'e

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2970. Dmitrevsky, A. A., The problem of analysis of a particular family of elementary, two-dimensional mechanisms (in Russian), *Trudi Leningrad Voyenn.-mekh. In-ta* no. 3, 63-68, 1955; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 8671.

It is demonstrated that a quintuply-linked hinged mechanism represents the general case for a family of two-dimensional, quadruply-linked mechanisms. The calculation formulas required for kinematic analysis, derived for the aforesaid quintuply-linked mechanism, are found suitable for kinematic analysis of the mechanisms derived therefrom. Proof is given of the possibility of using the said formulas for the kinematic analysis of multiply-linked, two-dimensional mechanisms. V. A. Zinov'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2971. Meyer zur Capellen, W., Harmonic analysis in elliptical crank slides (in German), *ZAMM* **38,** 1/2, 43-55, Jan./Feb. 1958.

If a straight line slides through a fixed point A in such a way that one of its points describes a given ellipse E, a crank-slide mechanism is produced of which the circular crank-slide oscillator is a special case. The elliptic motion may be generated by a Cardan mechanism. Author considers first the special cases: (1) A coincides with E's center; (2) one of the axes of E is zero. The more general case is restricted to that in which A is on one of the axes of E; it is treated by comparing it with a coupling of circular loops, and a Fourier analysis of the latter is made use of.

O. Bottema, Holland

2972. Volvich, S. I., A new method for calculating the stability of hinged-bar systems (in Russian), *Trudī Saratovsk. Avtomob. Dor. In-ta* no. 13, 16–24, 1955; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7201.

Variational equations are derived for the stability of equilibrium of hinged-bar systems loaded at the joints. The undisturbed or static condition is assumed to be that in which deformation is absent, and the expression for the critical parameters is obtained by equating the second variation of the potential energy of the system to zero (differing from the ordinary energy method in which the undisturbed state is assumed to be the state of deformation preceding the loss of stability). The generalized coordinates characteristic for the deformation are represented by either the coordinates of the joints or the angles of rotation of the (frame) bars. In the latter case

$$\delta^2 U = \sum_{i,k,m} \left(\frac{\partial S_m}{\partial \varphi_i} \frac{\partial S_m}{\partial \varphi_k} \frac{l_m}{EF_m} + S_m l_m \frac{\partial \varphi_m}{\partial \varphi_i} \frac{\partial \varphi_m}{\partial \varphi_k} \right) \delta\varphi_i \delta\varphi_k \qquad [1]$$

in which S_m = forces in the bars, l_m their initial lengths, φ_m angles of rotation of the bars. The critical parameters of the loading are determined by the condition of equality to zero of the determinant of quadratic form of [1]. V. V. Bolotin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2973. Oki, I., and Kawakami, K., Characteristics of disc valves of high-lift safety-valve type (experimental research on disc valves, 4th report), *Bull. JSME* **1,** 3, 286–292, Aug. 1958.

The characteristics of flat-seated valves provided with guide cylinders as used in some types of safety valve are treated in this paper.

Discharging water through a valve (39 mm in diam) under a constant head of about 2 m, either into the air or into the vessel filled with water, authors measured the discharge and lifting force for each valve lift, thus observing the performance of the guide cylinder.

To eliminate the effect of the cylinder edge, the guide cylinder was kept always a little higher than the valve, while the water was issued into the air. Under these conditions the discharge and the lifting force was measured, as well as the angle of jet, for each of the flat-seated valves of nine kinds, widely differing in diameter ratios. The relations between the quantities thus obtained were made clear by the use of the momentum equation.

From authors' summary

Fastening and Joining Methods

(See also Rev. 3102)

2974. Norris, C. B., and Heller, J. T., Mechanism of reinforcement of reinforced plastics, WADC TR 58-356, 32 pp. + 8 tables + 14 figs., May 1958.

A technique is developed for determining the rigidity of the bond between reinforcing strands of glass fibers and the resin in which they are embedded. This technique involves a method of accurate determination of the tensile stiffness of the strands; a method of casting small beams of resin reinforced with glass strands that are concentrated near one edge; an accurate method of testing such beams centrally loaded so as to induce shear between the strands and the resin; and a method of calculating the shear force on the strands, the bending stiffness from the test, and the expected bending stiffness if the bond is infinitely rigid. Comparison between the calculated stiffness of the beam and its test value in bending yields a measure of the shear rigidity of the bond between the strands and the resin.

This technique is described in detail, and some results are given for Epon 828 resin reinforced with glass strands that consist of 204 individual filaments, each about 0.00038 inch in diameter. The filaments were finished with starch-oil or A-1100 finish or heat-cleaned. From authors' summary

2975. Eickner, H. W., Evaluation of structural metal-bonding adhesives for bonding glass-fabric laminates to metals, WADC TR 58-364, 9 pp. + 10 tables + 4 figs., Apr. 1958.

An investigation was made by bonding lap-joint panels of glass-fabric laminates to aluminum alloy and to stainless steel with nine structural metal-bonding adhesives to determine if these adhesives were also suitable for this type of bonding. Test data were obtained on the aluminum-plastic bonds at −67 F, at 70 to 80 F, at 350 F, and after a 30-day exposure to salt water spray. The stainless steel-to-plastic bonds were tested at 70 to 80 F, at 350 F, and at 500 F. Laminates prepared with four representative types of resins were included in this research.

Lap-joint strength values generally averaged from 2000 to 2500 pounds per square inch at −67 F, at 70 to 80 F, and after 30 days exposure to salt water spray. However, at 180 F some of the adhesives started to lose strength, and, in tests at 350 and 500 F, only the strength values of the more heat-resistant adhesives exceeded 650 pounds per square inch. Strengths at the higher temperatures were generally better on the plastic laminates prepared with heat-resistant resins. The results indicated that a number of adhesives, as presently formulated to qualify for structural bonding of metals, will adequately bond glass-fabric laminates to metals. No special requirement or specification is required, therefore, for adhesives for this type of bonding, other than the existing specifications on metal-bonding adhesives.

From author's summary

2976. Doussin, L., Constitution of adhesives and properties of adhesive joints (in French), *ONERA NT* 43, 15 pp., 1958.

Rheology

(See also Rev. 2876)

Book—2977. Bernhardt, E. C. (edited by), Processing of thermoplastic materials, New York, Reinhold Publishing Corporation, 1959, xv + 690 pp. $18.

This book, the first of its kind in the field, is a comprehensive review firmly based on classical theoretical foundations.

Editor's introduction states that book deals with specific area of plastics processing, a new engineering speciality: the modification and conversion of basic thermoplastic polymeric materials to finished articles through to consideration of quality and interaction of processes on it. Thermosetting technology is so different as to require different treatment and is not considered in this volume.

Book is divided into three parts:

Fundamentals Section deals with basic theories of flow behavior, heat transfer and mixing. This section in a sense represents the philosophy of the authors—shared and applauded by reviewer—that plastics technology is not a "black art" with esoteric techniques and jargon, roped off from the rest of engineering, but that its problems yield to the sound use of classical theory.

Flow Behavior starts with consideration of ideal materials—normal liquids—and explains departures of plastics into other bodies with different properties. Treatment progresses clearly through models of bodies to consideration of practical effect of their different rheological behavior. Theory is based on Posieuille's and Navier-Stokes equations with alternative modifications to viscosity to account for non-Newtonian materials.

Heat transfer and thermodynamics is very simply treated with worked examples showing application to cases of practical interest in the field.

Mixing and Dispersing covers well the available statistical conception of subjects and shows application of mixing of solid polymer cubes to give good premix and also to mixing of molten polymers in continuous and batch machinery.

Author cites the basic literature in the field and contributes ideas of his own in good theoretical exposition, largely devoted to rigorous binomial treatment in the case of solids mixing. Reviewer prefers (cited) method of Adams and Baker using particular solution of Poisson on grounds of simplicity in use by engineers faced with testing and choosing blenders.

Second section titled "Applications" develops theories of first and shows their relevance to the basic methods of processing plastics: extrusion—deservedly given pride of place and length since it is at the root of other primary operations, injection moulding, calendering, mixing and dispersing; the section also deals with the secondary operations of sheet-forming, forming of hollow articles, sealing and welding.

Extrusion is very thoroughly done and assembles the important worldwide work to which the most important contribution is that of the authors themselves and their colleagues at du Pont.

Theory is clearly expressed, soundly based and well interpreted; discussion of real issues is practical with much useful advice.

Flow theories are taken through the approximate solutions up to the more rigorous ones, and an estimate given of the errors made by ignoring some of the most complex corrections. Theory enables predictions of output, pressure and temperature of melt from given screw and die or of screw and die design for particular operating conditions in single-screw machines. Practical systems of equipment are briefly discussed for making tube, sheet, film and cable. High-speed extrusion has not been touched on, but basic treatment supports theory behind this work. A theoretical analysis of twin-screw extruders has again been left to someone else.

Injection Moulding describes the main types of machine available and the function of granule geometry. Chapter is up to date in dealing with mixing and improved-heating nozzles. There is a good description of moulding quality and the variables affecting it. The value of preplasticizing and preweighing as an aid to quality is highlighted, but screw preplasticizing deserves more attention than authors have given in view of its greater efficiency in melting polymers and since more and more machines based on the combination of extrusion and injection are being designed the world over. Disappointing too is the absence of discussion of pressure loss distribution and nature of transient pressures in the system.

Calendering deals with theory of flow in nip and description of basic method and problems. The most modern solutions to accurate gage control are discussed.

Mixing and Dispersing carries on where fundamental chapter left off. This part describes two-roll mills such as mixers, the internal mixer of Banbury type and also extruders. Reviewer finds this chapter weak in some directions. On theoretical side author follows papers by Mohr, Saxton and Jepson on laminar flow mixing in single-screw extruders. While the argument is correct, this type of mixing appears to be of different order to random mixing described by Dankwerts, et al., since former reduces size of particular differences *normal* to laminar axis while leaving them aligned *along* the axis, giving effect of streaks, however small. Reviewer prefers to accept view that effect of shear is limited to drawing out and reducing original parallel flow streaks but that effect is limited to directional reduction and that some additional mechanism in continuous machine is required to randomize these streaks, i.e. to provide cross flow. Mixing heads are available to provide this by multiple cutting and folding actions. This concept has advantage of lowering ratio of work input per pound and raising machine outputs with same dispersion.

Discussion of internal mixers is a little abstract; reviewer feels that more should have been said on practical operation of internal mixers which have far greater merits as compounders compared with two-roll mill than author gives credit. Machines are highly efficient, particularly if mix is worked at maximum viscosity. Thus, high intensity machines are designed to give maximum cooling surface/volume ratio, high ram pressures and rotational speeds. Empirical and theoretical awareness of this approach is high in some designers, for example Farrel-Birmingham and Wehrner-Pfleiderer. Reference to "Polythene" edited by Morgan & Renfrew, chap. 4, 1957 and "Continuous compounding of thermoplastics" by D. Grant, *Rubber and Plastics Age* p. 481, June 1958, would have been useful. Regrettably no mention appears of Welding Engineers twin-screw machine which reviewer found gave better results and is better engineered than Ko-Kneader in rigorous plastic compounding. The chapters on forming of sheet and of hollow articles give straightforward account of machines and materials. Sealing and welding is thoroughly covered with some theory and examples.

The third section gives basic data on wide range of thermoplastic polymers, enabling insertion in flow equations developed through the book.

The newness of subject is seen in fact that hardly a reference dates before 1950. Most relevant work has been cited and considered. Book is highly recommended both to newcomers to industry and to engineers and technologists in it. It is a fine example of value of theoretical study contributing to the advance of practical techniques. Editors and collaborators have done a first-class job. Reviewer predicts book will be a "bible" in hands of many.

A. Kennaway, England

2978. Metzner, A. B., Fracture of non-Newtonian fluids at high shear stresses, *Indust. Engng. Chem.* **50,** 10, 1577–1580, Oct. 1958.

Extrusion rates of molten polymers may be limited by the stresses at which irregularities in flow rates and product shape begin. The irregularities increase rapidly with further increases in stress and may lead to fracture of the product filament, tube, or sheet. This article reviews the prior art, to help define the causes of this phenomenon and means for its control.

From author's summary

2979. Dodge, D. W., and Metzner, A. B., Turbulence in non-Newtonian systems, AFOSR TN-58-94 (Univ. Del., Chem. Engng.; ASTIA AD 148 143); 55 pp. + 20 figs., Feb. 1958.

A theoretical analysis for turbulent flow of non-Newtonian fluids through smooth round tubes has been performed for the first time, and has yielded a completely new concept of the attending relationship between the pressure loss and mean flowrate. In addition, the analysis has permitted the prediction of non-Newtonian turbulent velocity profiles, a topic about which the published literature is entirely void.

To confirm the theoretical analysis, experimental data were taken both on polymeric gels and solid-liquid suspensions under turbulent flow conditions. Fluid systems with flow-behavior indexes between 0.3 and 1.0 were studied at Reynolds numbers as high as 36,000. All of the fully turbulent experimental data supported the validity of the theoretical analysis. The final resistance law correlation represents a generalization of von Karman's equation for Newtonian fluids in turbulent flow, and is applicable to all non-Newtonians for which the shear rate depends only on shear stress, irrespective of their rheological classification. All the turbulent experimental data were for the non-Newtonian systems correlated by this relationship with a mean deviation of 1.9 percent.

Some polymeric gels are shown to deviate from the above relationship, possibly due to elasticity effects. While preliminary results are also presented for such systems, further work will be necessary to define turbulence quantitatively in these systems.

From author's summary

2980. Tyabin, N. V., Flow of an anomalously viscous fluid between two plane plates and two coaxial cylinders (in Russian), *Zh. Tekh. Fiz.* **26**, 9, 1994-2001, Sept. 1956.

Paper gives an approximate analysis of the flow of a non-Newtonian fluid. This incompressible fluid is characterized by the fact that the shear stress is some arbitrary function of the velocity gradient. The problem is solved by dividing the fluid into a number of regions whose boundaries are along the flow direction. In each of these regions, the shear stress is linearized subject to the restriction that the stress distribution and velocity distribution are continuous across the boundary to each region. For flow between parallel plates this condition provides a relation between shear at the wall and the pressure gradient. In the case of flow between concentric cylinders, the continuity of stresses relates the torque and shear at the wall.

In the case of flow between parallel plates, it is found that the ratio of mass flow to pressure drop is equal to the Newtonian value based on wall properties plus a correction which is essentially the ratio of the average shear cubed to the pressure drop cubed.

The technique of solving nonlinear differential equation by piecewise linearization is not new, although it has become fairly commonly applied to certain classes of engineering problems only in the past decade or so. In fluid mechanics the process corresponds to using a geometry in which the Navier-Stokes equations would be linear if the viscosity were constant. Consequently it is expected that the main value of this type of calculation is to serve as a comparison with other approximations.

E. E. Covert, USA

2981. Asanuma, T., and Sawa, N., Studies on the sealing action of a viscous fluid, *Bull. JSME* **1**, 3, 269-274, Aug. 1958.

In a previous paper, it has been shown that the pump lift or the sealing pressure is proportional to the viscosity of the working fluid. Authors have therefore carried out some experiments, using greases of viscosity higher than that of liquid oils.

A summary of the results is as follows:

(a) The sealing pressure for the grease is proportional to the rotor speed (N) and the coefficient of sealing performance (S), as shown in the previous papers for oils.

(b) When using some greases, the sealing pressure is about 30 to 70 times that for oils.

(c) The filling state of greases in grooves of rotating shaft is considerably varied with the kinds of greases, so that we must select the suitable depth of groove.

(d) To keep the viscosity of the sealing substance at a higher value, it is extremely important to cool the sealing apparatus.

From authors' summary

Hydraulics

(See also Revs. 2785, 2896, 3039, 3051, 3103, 3128, 3129, 3142, 3160, 3161)

Book—2982. Streeter, V. L., Fluid mechanics, 2nd ed., New York, McGraw-Hill Book Co., 1958, viii + 480 pp. $7.50.

The breadth and depth of coverage of fluid mechanics in this undergraduate textbook is considerably greater than in most American textbooks for undergraduate engineering students.

The book is divided into two parts: Part One is titled "Fundamentals of fluid mechanics" and Part Two is titled "Applications of fluid mechanics."

In Part One, the chapter headings are as follows: Chapter 1. Fluid properties and definitions; Chapter 2, Fluid statics; Chapter 3, Fluid-flow concepts and basic equations; Chapter 4, Viscous effects—fluid resistance; Chapter 5, Dimensional analysis and dynamic similitude; Chapter 6, Frictionless compressible flow; and Chapter 7, Two-dimensional ideal fluid flow. The problems and illustrative examples are chosen from all branches of engineering.

In Part Two, the chapter headings are as follows: Chapter 8, Turbomachinery; Chapter 9, Measuring of flow; Chapter 10, Closed-conduit flow; Chapter 11, Flow in open channels; and Chapter 12, Automatic fluid controls—Oil hydraulic systems.

Author is eminently qualified to prepare a textbook of this type.

M. R. Carstens, USA

2983. Kartvelishvili, N. A., Application of methods of mathematical analysis to hydroenergetics (in Russian), *Trudí Mosk. Energ. In-ta* no. 19, 18-27, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 7897.

Author expresses a number of critical observations on the existing method of discharge control and is of the opinion that modern theory furnishes two methods of calculation—the method of calendar series and the method of generalized static characteristics, while both methods contain an assumption on the stationary state of the discharge. Author claims that a theory for the control of the process of discharge can be built up by making use of the contemporary theory of stochastic processes, admitting that the higher functions of distribution of the stochastic variable will be normal functions. Some concepts are given regarding the application of this method to the concrete case of control on the guaranteed curve of energy output, and an expression is deduced for providing for the covering of the guaranteed curve of loading. Another problem was the building of a 24-hour GES control, taking into account the irregular region of the "lower water" of the hydrostation. Author brings forward a group of equations determining this problem, and gives his ideas on the methods of solution.

S. Ya. Vartazarov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

2984. Chertousov, M. D., The hydraulic calculation for flooded orifices when there is an outflow from under a shield (in Russian), *Izd. Vses. N.-i In-ta Gidrotekhn.* **54**, 214-219, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5553.

Article is devoted to the calculation of the reestablishment of the kinetic energy of the current in the "under" water of flooded installations when determining their capacity. Following the lead of other investigators [see, for instance, I. I. Levi, *Izv. N.-i In-ta Gidrotekhn.* **6**, 1932], author makes use of the joint solution of Bernoulli's equation and of the equation of the quantity of motion and obtains, unlike Levi, an explicit expression for the determination of the discharge of water when flowing from the flooded orifice in conditions of the plane and spatial problems. The calculation relations recommended in the article are adequately confirmed by the experimental data. On the basis of the relationships obtained and of the experimental data it is established that disregard of the reestablishment of kinetic energy in the "under" water of the flooded orifices may result in a loss of their outflow capacity by as much as 40%.

M. F. Skladnev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

2985. Emtsev, V. T., and Slisskii, P. M., Calculation of the union between the upper water and lower water behind terraced dam spillways (in Russian), *Gidrotekhn. Str-vo.* no. 8, 40-43, 1953; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 516.

Book—2986. Lilic, B. S., Hydraulic network for water supply [Raspodela Protoka u Hidraulickim Mrezama], Beograd, Yugoslavia, Univerztet u Beogradu, Electrotehnicki Fakultet, Posebna Izdanja, 1958, 120 pp.

"Hydraulic network for water supply" is an elementary book for engineers working with water supply. The book contains 119 pages and is divided into three major chapters.

The first and second chapters treat the known problem of water distribution in hydraulic networks. The method utilizes, as most readers well know, the analogy that exists between electrical circuits and hydraulic systems, i.e. the first and the second Kirchhoff laws. Here the author falls short of his avowed purpose of making an engineeringly tangible presentation rather than an adjunct to mathematics. The third chapter generally discusses the system of algebraic equations appearing in common hydraulic networks.

The book is clearly and simply written but does not introduce a new method. Practicing engineers and undergraduate students could use this book. M. M. Stanisic, USA

2987. Zhuravlev, P. A., On the motion of a fluid in channels (in Russian), *Zap. Leningr. Gorn. In-ta* **33**, 3, 54–61, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4262.

An examination of certain properties of a field of velocities, as well as the geometry of a plane incompressible steady flow. The corresponding complex potential is taken in the form

$$\omega = Uz + \frac{m}{2\pi} \ln \cos \frac{\pi z}{ai} \quad (z = x + iy)$$

A similar flow was examined earlier in certain problems of steady filtration of an incompressible liquid in a horizontal layer.

V. P. Pilatovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2988. Kovalev, Ya. T., Criterion for the flooding of a bottom water sluice of circular section in the presence of motion under pressure (in Russian), *Sb. Rabot. Beloruss. Politekhn. In-ta* no. 54, 63–70, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5541.

The error, established previously by other authors, is confirmed in regard to the determination of the capacity of pressure-water conduits in the case where the acting pressure is taken to be equal to the difference in levels of the "upper" and "under" water when the "under" water is situated higher than the center of gravity of the outlet section and equal to the increase in height of the water level of the "upper" water above the center of gravity of the outlet-opening when the level of the "under" water is lower than the center of gravity of the given opening. Making use of the equation of the quantity of motion, author determines the depth of the water h_2 in the run-off channel of the pressure water conduits, coupled with the depth of water in the outlet section. Author recommends that the water conduit should be considered not flooded if the actual depth h_2 of the "under" water is less than the depth h_2. In the opposite case the water conduit should be considered flooded. It is necessary to mention that the establishment of the criterion for flooding of the pressure water conduit does not solve the question of the correct determination of the capacity of this installation [see, for instance M. E. Faktorovich, *Izv. Vses. N.-i. In-ta Gidrotekhn.* **34**, 1947].

A rejoinder is called for by author's recommendation for the calculation of the impulse of pressure forces in the plane of the outlet section of the water conduit with the help of the coefficient ξ. Author's method of proof for his recommended values for this coefficient is not convincing, as the comparison of the experimental data with the theoretical calculation, including in itself coefficient ξ, is carried out on the basis of the very same experiments and relations which were used to establish the numerical values of the given coefficient. In this connection, the numerical values of coefficient ξ brought into the article cannot be accepted on conditions differing in however a small but essential degree from the conditions observed in author's experiments.

M. E. Faktorovich

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2989. Zhamagortsyan, V. N., and Ovsonyan, K. Kh., A method of measuring wave perturbations in laboratory investigations on the unsteady motion of a fluid (in Armenian), *Izv. Akad. Nauk ArmSSR, Fiz.-Matem. i Tekhn. Nauk* **9**, 6, 77–84, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 8966.

The layout is described of the entry end of an instrument for measuring the variations of a water-level by electrical means. The instrument enables waves of up to 8–10-cm height to be recorded. P. A. Volkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Incompressible Flow

(See also Revs. 2763, 2765, 2773, 2981, 2982, 3014, 3017, 3027, 3043, 3044, 3049, 3055, 3062, 3079, 3088, 3127, 3130, 3136, 3177, 3191)

2990. Mateescu, Cr., New methods for the determination of velocity distribution in steady laminar flow of viscous fluids (in English), *Acad. Repub. Pop. Romine, Rev. Mecan. Appl.* **3**, 2, 41–60, 1958.

Paper concerns the determination of velocity distribution in the laminar flow of a viscous fluid, through approximate methods applicable to steady motions. A first procedure proposed belongs to the general class known as relaxation methods and uses a curvilinear network. Each mesh of this network is considered to be the cross section of a stream tube. The finite difference equations are obtained directly from the motion equations written for each of these tubes. The approximations introduced are then discussed and a few examples are given.

The second procedure consists in superimposing two steady uniform motions in rectilinear tubes, having the same piezometric line and the same viscosity. The velocity distribution for motions whose boundaries differ from those of the initial motions is thereby obtained. Considerations on the equal velocity curves are finally presented. T. Oroveanu, Roumania

2991. Franke, P. G., Frictional losses of head in steady uniform flow, *J. Sci. Indust. Res., India* **17**, 8, 289–296, Aug. 1958.

Review of recent studies in field of uniform flow, deriving from Colebrook's formula; the developments in series by Supino are especially considered, for which a numerical table is given. The free surface flow in circular conduits is considered also. Author suggests the expression $C = K R^{1/8}$ of the Chézy coefficient as a good approximation for Colebrook's formula.

D. Citrini, Italy

2992. Carpenter, L. H., On the motion of two cylinders in an ideal fluid, *J. Res. Nat. Bur. Stands.* **61**, 2, 83–87, Aug. 1958.

Paper determines the two-dimensional flow of inviscid incompressible fluid due to two cylinders of radii b and b' with parallel axes distant f apart. One cylinder alone is equivalent to a doublet. The second cylinder gives rise to an image doublet; this has an image doublet due to the first cylinder and so on. Similarly a series of doublets arises from the second cylinder. Thus the complex potential is expressible in the form of the sum of two series. These series converge rapidly if $b\,b'/f^2$ is small, and, according to the paper, one term of each series, together with an approximation for the remaining terms, gives an accurate result if $b\,b'/f^2 = 1/16$. Even in the limiting case of $b\,b'/f^2 = 1/4$ only three terms of each series are needed. Method may be extended to any number of cylinders.

Applications to the flow induced by a cylinder in the presence of plane boundaries are given and the streamlines are illustrated in certain cases. J. C. Cooke, England

2993. Yen, K. T., On the indeterminateness of the boundary conditions for a mixing problem, Rensselaer Polytechnic Inst., TR AE 5710, 13 pp., Dec. 1957.

Results obtained from a study of the indeterminateness of the boundary conditions for laminar mixing of two "free" parallel streams under constant pressure are presented. A method is given for determining the interface velocity in the mixing region as well as the transverse force acting on the dividing wall as a consequence of the mixing. Numerical examples are given to show that values of interface velocity obtained by author differ appreciably from those obtained by using other proposed boundary conditions (the third condition). From author's summary

2994. Ueda, T., Studies on the flow of air-water mixtures—the upward flow in a vertical tube, *Bull. JSME* **1**, 2, 139–144, June 1958.

Results are presented for the following three experiments on the upward flow of air-water mixtures in a vertical tube having an inside diameter of 51 mm: (a) Visual observation of the flow patterns. (b) Measurement of the static pressures along the tube. From these results, the volume fraction of air in the tube and the relative velocity of air were calculated. A tentative correlation is presented about the drag coefficient of the force acting between air and water owing to the relative velocity. (c) Measurement of the tube wall temperature under a constant heat rate. The flow rates include the range of 200 to 5000 kg/h for water and 0 to 45 kg/h for air.

It seems that obstacles in tubes have particular effects on the flow of air-water mixtures. Some experiments were also performed to make qualitatively clear the effects of obstacles inserted into the vertical tube. From author's summary

2995. Katsuhara, T., Pressure drop due to friction for parallel flow of mixtures of vapor and water in a downcomer, *Bull. JSME* **1**, 2, 145–149, June 1958.

Author experimentally investigated the pressure drop due to friction for the flow of water containing bubbles in a non-heated downcomer.

First, the pressure drop due to friction and dryness fraction for the parallel downward flow of the mixtures of air and water were measured in a vertical 1500 mm long and 19-mm inside-diameter glass pipe. Next, the ratios of the coefficient of friction in high-pressure regions were extensively computed from the results of the above experiment. Finally, when non-heated downcomer was used it was proposed that 0.03 be adopted as an approximate value of the coefficient of friction.

From author's summary

2996. Chilton, H., A theoretical study of stability in water flow through heated passages, *J. Nuclear Energy* **5**, 273–284, 1957.

By mathematical analysis based on one-dimensional-flow formulas, author develops useful design criteria for stable flow in boilers. Here, stability means avoidance of conditions where a specified pressure loss can be satisfied by two or more mass flow rates. In a boiler having multiple tubes in parallel such conditions could result in highly uneven flow distribution. Analysis is presented in terms of water cooling an atomic reactor, but the results should apply to any boiler, as long as the heat flux does not depend on the mass flow. Reviewer would have liked more discussion of buoyancy; author's only comment is "When flow in the passages is in a vertical direction, buoyancy effects are seldom completely negligible. Suitable corrections in particular cases are applied at relatively advanced stages of design." Reviewer suspects these corrections may be quite large in certain cases.

R. R. Hughes, USA

2997. Marke, P. W., and Marstrand, J., Outflow of steam through long pipelines (in English), *Ingenioren* **2**, 4, 132–138, Nov. 1958.

Compressible Flow (Continuum and Noncontinuum Flow)

(See also Revs. 2884, 3021, 3022, 3056, 3057, 3058, 3074, 3105)

2998. Cochran, D. L., and Kline, S. J., Use of short flat vanes for producing efficient wide-angle two-dimensional subsonic diffuser, *NACA TN* 4309, 66 pp. + 9 tables + 39 figs., Sept. 1958.

Paper is extension of work reported in previous papers [AMR **11** (1958), Rev. 4612]. Prime objective is solution to wide angle, subsonic diffuser problem and secondary objective is to add to knowledge of flows with adverse pressure gradients. Experiments were performed in both water table studies and air flow tests. Apparatus is pictured in report.

Experimenters vary diffuser divergence angle, ratio of diffuser length to initial entrance opening, number, length, and angle of vanes, in scheduled program. They measure flow rate, pressure recovery, and profiles in planes at various axial distances. Wall tufts are used for flow visualization. Trip wires are included in all tests to insure turbulent boundary layer.

Results are given in form of pressure recovery coefficient, pressure effectiveness (ratio of actual pressure recovery coefficient to ideal), and criteria describing regimes of diffuser flow. For diffuser configuration studied, conclusions are that vanes should be in vicinity of throat, vane divergence angle should be about 7°, and optimum vane length should be calculated from several parameters involving diffuser geometry.

Reviewer believes paper to contribute materially to diffuser technology. H. L. Bloom, USA

2999. Hopkes, U., Measurements on two-dimensional cascades at high subsonic Mach numbers. Part II. Measurements of loss coefficients (in English), AFOSR TN 57-289a (Inst. Aerodynamik der Deutchen Forschungsanstalt für Luftfart, Braunschweig, Rep. 57/23a; ASTIA AD 132 360a), 25 pp. + 1 table + 13 figs. Jan. 1958.

In a previous report, pressure-distribution measurements on two-dimensional cascades at high subsonic Mach numbers were given, the blade sections being NACA 0010 and NACA 8410, varying the solidity ratio, the blade angle, and the angle of inflow. In this report measurements of loss coefficients of cascades at high subsonic Mach numbers are presented, continuing the previous investigations. These measurements have been done for constant Reynolds number, but varying Mach number, and were mainly to test the new experimental set-up for wake-survey measurements in the Variable Density High-Speed Cascade Wind Tunnel of the Deutsche Forschungsanstalt für Luftfahrt, Braunschweig.

From author's summary

3000. Sakurai, T., Flow past a bent flat plate with an unsymmetric dead air at Mach number 1, *J. Phys. Soc. Japan* **13**, 9, 1055–1060, Sept. 1958.

This mathematical solution represents the sonic two-dimensional flow around bent plates for the ideal case where the zero streamline touches tangentially the leading edge of the plate. Transformation of the physical plane into the hodograph plane is given under the assumption that free streamlines depart at the trailing edge of the rear part of the plate and at the outside corner of the flap angle, thus fixing dead air region.

Theory, the origin of which is a special transformation method by I. Imai, studies the airfoil characteristics for the case when the angle of incidence is identical with the angle of tangential flow entrance. This angle is here dependent on the flap angle, which also determines the lengths of the front and rear part of the plate. The present exact theory and an attached approximation give the lift coefficient and lift distribution over the chord length of plate. Three diagrams show lift distribution. Numerical values for the

geometrical conditions of the bent plate and the two lift coefficients are tabulated for five cases of the flap angle. Formulas allow the calculation of other closely connected cases of the geometry of the bent plate and other flap angles.

F. W. Keune, Germany

3001. Powley, M. B., Flow of compressible fluids, *Canad. J. Chem. Engng.* **36,** 6, 241–245, Dec. 1958.

Previously derived equations describing compressible flow have been rearranged in terms of known downstream conditions to facilitate determination of unknown upstream conditions. A 650 IBM computor was used to solve the simultaneous equations numerically to permit construction of convenient design graphs in parametric form. Use of these graphs will eliminate a tedious trial-and-error computation formerly necessary with presently available methods when the upstream pressure and temperature are to be determined in gas flow problems. Application to design is illustrated by a worked sample. From author's summary

3002. Clarke, J. H., Reverse flow and supersonic interference, AFOSR TN 58-625 (Brown Univ., Div. of Engng.; ASTIA AD 162 155); 40 pp., July 1958.

From a volumetric formulation of the momentum theorem of linearized theory, a general analytic proof is presented, as a preliminary, of the invariance of the drag of an arbitrary spatial distribution of horseshoe vortices and sources under reversal of the undisturbed flow. By consideration of the interference drag of two such singularity distributions, a reverse-flow relation for steady subsonic or supersonic flow is obtained. The relation, a generalization of the Ursell-Ward theorem, may be applied to configurations with bodies whose surfaces are not quasi-cylindrical and whose surface pressures are quadratically related to the perturbation velocity.

The relation is used to discuss several interfering two-body arrangements in supersonic flow. It is shown that, in certain cases, the drag and lift may be determined without knowledge of the interference flow field associated with the arbitrarily prescribed body geometry. The simplicity of the results permits the formulation of optimum problems. The invariance of the drag under flow reversal with unchanged geometry is also established. The role of edge forces in the results is discussed.

From author's summary

3003. Thyagarajan, C., and Yen, K. T., Study of some supersonic rotational flow problems by a perturbation technique, AFOSR TN 58-624 (Rensselaer Polytechnic Inst., TR AE 5803; ASTIA AD 162 154); 23 pp. + 4 figs., Apr. 1958.

A small perturbation technique using generalized coordinates formed by streamlines and their orthogonal trajectories is applied to the analysis of some supersonic rotational inviscid flows. With a properly prescribed pressure distribution on a body surface in generalized coordinates, the body shape and the pressure field in the physical plane can be determined.

Using a conveniently chosen initial Mach number distribution, two examples have been studied in some detail. The first one is concerned with a linear surface pressure distribution which gives a nearly wedge-shaped body in the physical plane. It is shown that the wedge angle should be negative or positive depending on the slope of the vorticity distribution to create the pressure distribution prescribed.

To examine the phase shift of the pressure distribution for a supersonic rotational flow over a periodically wavy wall, a sinusoidal pressure distribution is chosen as the second example. It is shown that the phase shift also depends on the slope of the vorticity distribution. From author's summary

3004. Fenain, M., and Vallee, Denise, Effect of thickness, in a supersonic regime, for certain slender sweptback wings. Minimum wave drag (in French), *C. R. Acad. Sci., Paris* **246,** 4, 549–551, Jan. 1958.

These are symmetrical, nonlifting, sweptback wings with pointed tips, falling within the scope of the linearized theory of homogeneous flow fields. Both the "direct" and "inverse" problems of wing theory are considered. The basic results, for pressure distribution and surface slope, respectively, are carried over from earlier papers of the same authors [*Rech. Aéro.* no. 44, 1955; AMR **9** (1956), Rev. 1519]. A closure condition is required; in the indirect problem it limits consideration to wings with nonreentrant trailing edges. The wave drag is calculated in terms of the coefficients of the given polynomials (slope or pressure distribution). The volume of the wing can also be expressed in these terms. Thus minimum-drag wings have been designed, and it is stated that significant drag reductions are found. W. R. Sears, USA

3005. Fabri, J., and Siestrunck, R., Supersonic air ejectors, Advances in Appl. Mech., Vol. 5, edited by Dryden, H. L., and von Karman, Th., New York, Academic Press, 1958; 1–34.

Authors classify flow pattern appearing in a jet ejector into two groups: supersonic and mixed flows. In the former, primary jet is supersonic throughout mixing-tube and, in the latter, supersonic primary flow breaks down into subsonic due to shock waves, and subsonic turbulent mixing occurs in mixing-tube. For each flow pattern, conservation equations of mass, momentum and energy together with other supplementary conditions and assumptions form a complete set of equations for determining characteristic ejector performance. Between these flow patterns the one is chosen which induces a smaller amount of secondary flow. Experiments made with a variety of primary nozzle geometries show excellent agreement with theory. Experimental investigations are made of operation without induced flow, of parameters influencing ejector performance and of pressure distribution along mixing-tube. A chart is presented for the use in optimum jet-ejector design.

R. Kawamura, Japan

3006. Vinokur, M., Inviscid hypersonic flow near the stagnation point of oblate ellipsoidal noses, *J. Aero/Space Sci.* **25,** 7, 469–470 (Readers' Forum), July 1958.

Author obtains a solution for incompressible flow analogous to Lighthill's solution [*J. Fluid Mech.* **2,** 1, 1–32, Jan. 1957] for a spherical nose. Comparison of stagnation point velocity gradient with Probstein's results [Brown Univ. Report. Sept., 1956, "Inviscid flow in the stagnation point region of very blunt-nosed bodies at hypersonic flight speeds"] indicates poor agreement for low values of the ratio of free-stream density to density behind the shock wave, although both results intersect at one point. No experimental results are shown. Inclusion of experimental results would have been useful for evaluation of the theories.

H. G. Lew, USA

3007. Scala, S. M., The injection of air into the dissociated hypersonic laminar boundary layer, *J. Aero/Space Sci.* **25,** 7, 461–462 (Readers' Forum), July 1958.

Mass transfer in a laminar boundary layer at a stagnation point of a blunt body for a binary mixture of atoms and molecules is considered. Air molecules are injected. Two cases of chemical constraints of local equilibrium and frozen flows are considered with variable Prandtl and Lewis numbers and fully catalytic wall. The effects of injection are as expected: the heat transfer and shear stress are reduced; moreover, the effect is about independent of the rate of homogeneous atom recombination. H. G. Lew, USA

3008. Trimpi, R. L., and Cohen, N. B., A nonlinear theory for predicting the effects of unsteady laminar, turbulent, or transitional boundary layers on the attenuation of shock waves in a shock tube, with experimental comparison, *NACA TN* 4347, 57 pp. + 1 table + 36 figs., Sept. 1958.

An unsteady incompressible local skin-friction coefficient is estimated for the laminar layer on the basis of a comparison of the Rayleigh solution for the impulsive motion of a plate from rest and the steady Blasius solution, but the steady power law solution is used as a basis for the turbulent boundary-layer skin-friction coefficient. Compressibility effects are then allowed for by the use of the intermediate temperature concept. Previous linear approach [*NACA TN* 3375, 1955; AMR **8** (1955), Rev. 3508] to the problem of attenuation is modified by treating the hot gas region in a series of steps in each of which the modification in flow characteristics introduced in previous steps is allowed for as far as the important forward running waves are concerned. The effects of the waves generated in the cold gas region and those of the backward running waves and of the waves reflected at the contact surface are taken to be adequately given by the linearized treatment. The nonlinear theory predicts in general smaller attenuation than the linear theory. Curves are presented for resulting attenuations for shock-pressure ratios up to 20 and shock-tube Reynolds number from 10^4 to 10^6. Comparison with experiment generally shows satisfactory agreement for a specified transition Reynolds number except in the case of high shock-pressure ratios and low tube Reynolds number, where the discrepancy may be due to imperfect bursting of the diaphragm, and in the case of low shock-pressure ratios, where it is suggested that the specified transition Reynolds number may have been incorrectly chosen. Reviewer suggests value of paper would have been enhanced and task of reader made easier if author had troubled to explain notation where introduced in the text.

A. D. Young, England

3009. Duff, R. E., Relaxation time for reactions behind shock waves and shock wave profiles, *Phys. Fluids* **1**, 3, 242–245, May/June, 1958.

Author develops expression for relaxation time for dissociation of a diatomic gas behind a shock wave. Wave profiles for strong shocks in O_2 are calculated for two different dissociation mechanisms, one of which includes the possibility of dissociation through ozone production. Calculations indicate that ozone is not an effective intermediate and can be neglected in the dissociation of O_2. Also indicated is the difficulty of defining a relaxation time that varies inversely with initial pressure for the entire reaction.

A. Ritter, USA

3010. Devienne, F. M., The revolving arm method and its application to rarefied gas dynamics and aerothermodynamics, AFOSR TN 58-709 (Lab. Méditerranéen de Recherches Thermodynamiques, Nice, France; ASTIA AD 201 866), 30 pp. + 6 figs., May 1958.

After stating the principle of the revolving arm method and the possibilities of measuring the stagnation temperature and the total pressure, the advantages and disadvantages of this method are discussed.

The essential advantage of the revolving arm method is that the experimental conditions are perfectly determined. In particular the pressure and the temperature of the gas, as well as the speed of the arm, are accurately determined.

The revolving arm method is, however, limited by the fact that it is impossible to reach extremely high speeds. Thus in the case of dry air it seems hardly possible to exceed a Mach number equal to 2.

In the free molecular flow regime or the transition flow regime the revolving arm method can be applied without correction for Knudsen number values greater or equal to 0.6 in the case of dry air. This value is also more or less the same for other gases with which have been studied the phenomena in the vicinity of the arm, namely, argon and carbon dioxide. At higher pressures, which correspond to lower Knudsen numbers, it is necessary to make some corrections in order to account for the heating of gaseous layers in the vicinity of the arm. From author's summary

3011. Litwiniszyn, J., Flows with the exchange of mass, momentum and energy (in English), *Arch. Mech. Stös.* **9**, 6, 669–684, 1957.

Problem is mathematical description of one-dimensional, transient flows in which mass, momentum, and energy addition or removal are considered. Treatment is applicable to problems of duct flows in gas burners and lines, jet propulsion systems, mine explosions, chemical supply lines. Kinematics and conservation equations are represented in general form and reduced for the case of a perfect gas to a quasi-linear nonhomogeneous system of first-order partial differential equations in v, ρ, and T (velocity, density, and temperature) of two independent variables x and t. The nature of these equations and problems of their solution are discussed. Paper is a sophisticated, general treatment of a basically mathematical problem for which many special cases have been published previously. E. W. Price, USA

Boundary Layer

(See also Revs. 3007, 3058, 3079, 3081, 3105, 3179)

3012. Hansen, A. G., and Herzig, H. Z., Approximate solutions of a class of similarity equations for three-dimensional, laminar, incompressible boundary-layer flows, *NACA TN* 4375, 21 pp. + 6 figs., Sept. 1958.

A method is presented for the approximate calculation of the three-dimensional laminar boundary layer when the main-flow streamlines are given as follows: The velocity component along x remains constant and the component perpendicular to x varies arbitrarily (expressed as a power series in terms of x with exponents n). The solutions are obtained by matching the two solutions; (1) Valid for large values of the similarity parameter $y\sqrt{U_e/\nu x}$; (2) valid for small values of the same parameter, at a value of the similarity parameter which is the smaller, the larger n is in the power series. In both solutions assumptions are made which become increasingly accurate with large n. The solutions are quite accurate even for small n in the neighborhood of the surface and, as the comparison with an exact calculation shows, in the whole region for $n = 10$. Particularly simple solutions at the surface for the flow deflection, the limiting streamline shape, and the shear stress there, are obtained when the power series consists of one power x only. H. P. Eichenberger, USA

3013. Yohner, Peggy L., and Hansen, A. G., Some numerical solutions of similarity equations for three-dimensional laminar incompressible boundary-layer flows, *NACA TN* 4370, 18 pp. + 3 tables + 8 figs., Sept. 1958.

In a former report [AMR **10** (1957), Rev. 1176] Hansen and Herzig obtained similarity solutions for three-dimensional incompressible laminar boundary layers. By introduction of a similarity parameter $\eta = y/(\nu)^{1/2}\, g(x,z)$, where y is the coordinate perpendicular to the surface, and assuming that the boundary layer profiles in x and z directions are determined by functions $F'(\eta)$ and $G'(\eta)$, the boundary-layer equations can be converted into ordinary differential equations for F and G, provided the free-stream velocities U and W as well as the function $g(x,z)$ depend in a special way on x and z. In the present report the differential equations for F and G have been solved numerically for two different functional relationships between U, W, g and the independent variables x and z. The free streamlines in the first case are parallel curves, thus representing qualitatively flows near a leading edge or stagnation line. In the other case the free streamlines are lines emanating from a point as in flows with a stagnation point.

By aid of the solutions found for F' and G' the boundary streamlines and, in particular, the limiting streamlines have been analyzed. A. I. van de Vooren, Holland

3014. Lighthill, M. J., On displacement thickness, *J. Fluid Mech.* **4,** 4, 383–392, Aug. 1958.

Four alternative theoretical treatments of displacement thickness, and, generally, of the influence of boundary layers and wakes on the flow outside them, are set out, first for two-dimensional, and then for three-dimensional, laminar or turbulent, incompressible flow. They may be called the methods of flow reduction, equivalent sources, velocity comparison, and mean vorticity.

R. C. Binder, USA

3015. Williams, J. C., III, On the laminar boundary layer with arbitrary pressure gradient and wall temperature distributions, AFOSR TN 58-583 (Univ. So. Calif. Engng. Center Rep. 40-204; ASTIA AD 162 103), 17 pp., July 1958.

The laminar boundary-layer equations for a compressible heat-conducting gas are first transformed by the Stewartson transformation. The transformed equations are then attacked by the Blasius series procedure which is well known in incompressible boundary-layer theory. This procedure yields a number of pairs of simultaneous ordinary differential equations which, when solved, define the boundary layer on a body with an arbitrary pressure distribution. The method also allows for an arbitrary wall temperature distribution or an arbitrary heat-transfer-rate distribution along the body.

The resulting equations can probably best be solved on modern high-speed computing machines. From author's summary

3016. Rosciszewski, J., An approximate solution of laminar boundary layer equations by means of polynomials, *Arch. Mech. Stōs.* **9,** 4, 381–394, 1957.

Many more or less successful attempts have been made by many authors to improve the Pohlhausen method by applying higher than fourth-order polynomials for the velocity profiles and, accordingly, fulfilling more necessary conditions than in the case of the original fourth-order method. [Cf. H. Schlichting, "Boundary layer theory," London, Pergamon Press, 1955, pp. 220, 221; AMR **9,** (1956); Rev. 215.] Author, who does not seem to be aware of these attempts, first applies a fifth-order polynomial, additionally fulfilling the second condition of compatibility at the wall as one further necessary condition, then a sixth-order polynomial, additionally prescribing a universal value for the Pohlhausen parameter at the separation point, this value chosen in close agreement with experimental data for many body forms. Accordingly, in the latter case all examples demonstrate considerable improvement in the prediction of separation points. However, no comparisons are made with reliable theoretical or with experimental results for any other details of the flows such as distribution of local wall shearing stress or velocity profiles. H. Gortler, Germany

3017, Fainzil'ber, A. M., The energetical form of the equations of motion of viscous liquids and an integral for slightly vortical flow (in Russian), *Dokladi Akad. Nauk SSSR (N. S.)* **106,** 5, 793–796, Feb. 1956.

This is a mathematical paper concerned with generalizing Bernouilli's theorem, as far as two-dimensional flow is concerned. If V = absolute velocity, U = gravitational potential energy per unit volume, p = pressure, ρ = density, ω = vorticity, ν = kinematic viscosity, a = arbitrary constant and

$$H = \frac{1}{2} V^2 + (p/\rho) + U + a\omega$$

it is shown (by applying the Navier-Stokes equations) that

$$dH/dt = \nu (\nabla^2 H - \omega^2)$$

If the vorticity is so small that the last term may be neglected, this equation is readily integrated, yielding H = const. This result can be applied in the theory of boundary layers.

R. Eisenschitz, England

3018. Yen, K. T., On a boundary layer approximation technique, AFOSR TN-58-403 (Rensselaer Polytechnic Inst., TR AE 5802; ASTIA AD 158 206), 24 pp., Apr. 1958.

The problem of two-dimensional steady viscous flow is formulated using the streamlines and their orthogonal trajectories as generalized coordinates. Based on this, two boundary-layer approximations are then developed. The first one, called the P-approximation, applies to boundaries with surface curvature equal to zero. This approximation is essentially equivalent to Prandtl's boundary-layer theory. The second boundary-layer approximation, called the C-approximation, is developed to study the effect of surface curvature. The conditions under which similar solutions exist for the C-approximations are obtained. Because of the complexity of the differential equations, high-speed computing machines will have to be used to obtain solutions of the C-approximation. From author's summary

3019. Karlsson, S. K. F., An unsteady turbulent boundary layer, Johns Hopkins Univ., Dept. Aero., 59 pp. + 20 figs., May 1958.

A parallel flow whose velocity fluctuates sinusoidally in magnitude about a constant mean has been produced in a boundary-layer wind tunnel. Hot-wire measuring techniques have been developed to permit an investigation of the turbulent boundary layer developing on a flat plate with this free-stream condition. The response of the layer at a Reynolds number $R_{\delta^*} \simeq 3.6 \times 10^3$ was measured for fluctuation amplitudes up to $\pm$ 34% of the free-stream velocity. The frequency of the free-stream fluctuations was varied from 0 to 48 cps.

Measurements were made of mean velocity, amplitudes of in and out of phase components of the first harmonic of the periodic fluctuations and the intensity of higher harmonics and turbulence. It was found that nonlinear effects, even at the largest fluctuation amplitudes, were so small that they were obscured by experimental errors. From author's summary

3020. Fedyaevskii, K. K., and Ginevskii, A. S., A method for the calculation of the turbulent boundary layer (in Russian), *Zh. Tekh. Fiz.* **27,** 2, 309–326, Feb. 1957.

Paper assumes three basic relationships for the turbulent boundary layer: (1) Karman momentum-integral equation; (2) Prandtl mixing-length formula $(\tau/\rho)^{1/2} = \kappa y \partial u/\partial y$; (3) single-parameter family for shearing-stress profile $\tau(y)$. Latter family, in view of (2), is now based on polynomial in y/δ for $(\tau/\tau_w)^{1/2}$ rather than τ/τ_w as in earlier work of first author [*Trudi TsAGI* 282, 1936; 316, 1937]. Boundary conditions are $\tau = \tau_w$ and $\partial\tau/\partial y = dp/dx$ at $y = 0$; $\tau = 0$ at $y = \delta$; parameter is $A = (\delta/\tau_w) dp/dx$. Integration of (2) yields velocity profile u/U as function of y/δ, with two parameters A and C_f. Intersection of latter curve with linear profile at wall, assuming constant sublayer Reynolds number, gives local friction law. Shape parameters for profile are computed and presented graphically. Attempt is made to integrate (1) for this profile; results are compared with experimental data from various sources.

Reviewer notes that comparison is satisfactory in engineering sense for flow with small pressure gradients, as is true for many alternative methods, but believes present formulation must fail for more difficult cases with large gradients or separation because of inadequacy of mixing hypothesis (2) for these cases.

D. Coles, USA

3021. Heil, M., Flows in partly dissociated gases, *J. Aero/Space Sci.* **25,** 7, 459–460 (Readers' Forum), July 1958.

Equations are given for a partly dissociated diatomic gas flow over a body of revolution, illustrating the effects of diffusion and the transition to equilibrium equations. H. G. Lew, USA

3022. Morduchow, M., Analysis and calculation by integral methods of laminar compressible boundary layer with heat transfer and with and without pressure gradient, *NACA Rep.* 1245, 19 pp., 1955.

Thorough summary of theoretical investigations at PIBAL on use and adequacy of integral methods for calculation of heat-transfer and skin-friction coefficients, separation and stability criteria for two-dimensional laminar compressible boundary-layer flow is given, and preferred methods for various flow conditions recommended.

Approximate methods of calculation of the boundary-layer characteristics are then developed, and underlying mathematical analyses are given in sufficient detail to show logical development, assumptions, and range of applicability of the methods. Examples are worked and results compared to those obtained from solutions of basic equations reported elsewhere in the literature. Agreement is shown to be adequate for most engineering purposes, and simplicity of computational methods (requiring at most a desk computer) emphasized. Extensive bibliography is included.

H. Hurwicz, USA

3023. Hartunian, R., Russo, A., and Marrone, P., Boundary-layer transition and heat transfer in shock tubes, Heat Transf. and Fluid Mech. Inst., Univ. of Calif., Berkeley, Calif., June 1958, 114–125.

Experimental study of the wall boundary layer in a shock tube over a wide range of shock Mach numbers (from 1.5 to 10) and pressure levels, including those for which dissociation effects exist. Shock Mach number range corresponds to wall-to-free-stream real-gas static temperature ratios of 0.07 to 0.8. At low cooling rates, transition depends chiefly on Reynolds number while high cooling rates exert a definite stabilizing effect on the boundary layer. Experimental results indicate that laminar heat-transfer rate is essentially constant over the shock Mach number range up to 7.5 and is inversely proportional to the square root of the Reynolds number; real gas effects become noticeable at the higher shock Mach numbers. Experimental results on the turbulent heat-transfer rate also agree with the existing theory; it is inversely proportional to the fifth root of the Reynolds number. E. A. Brun, France

3024. Scott, C. J., and Anderson, G. E., Boundary-layer transition with gas injection, *J. Aero/Space Sci.* **25,** 12, p. 791 (Readers' Forum), Dec. 1958.

The Mass-Injection Process has been proposed as a method of cooling aerodynamic surfaces, and, since the amount of coolant required to maintain practical wall temperatures is considerably larger for turbulent than for laminar boundary layers, knowledge of the effect of the cooling method on the transition process is certainly important. Exploratory studies reported here were conducted at Mach number 3.7 to ascertain the effects of gas injection on the stability of the laminar boundary layer on a conical surface.

From authors' summary

3025. McMahon, H. M., An experimental study of the effect of mass injection at the stagnation point of a blunt body, Guggenheim Aero. Lab., Calif. Inst. Technol. Memo. **42,** 80 pp. + 2 tables + 59 figs., May 1958.

An experimental study of the effect of the injection of nitrogen and helium coolant gases at the stagnation point of a blunt body was carried out in the GALCIT Hypersonic Wind Tunnel at a Mach number of 5.8. The gases were injected straight out of the stagnapoint and also tangential to the body surface. The model was also fitted with flow separation spikes.

The injection of the coolant gas resulted in a marked reduction in the model equilibrium temperature, and this cooling effect persisted over the entire length of the model. For the same mass flow, helium was a better coolant than nitrogen.

The average heat transfer near the nose of the body was reduced almost to zero by injecting a mass flow of helium as small as ½% of the mass flow of free-stream air contained in the "capture" area πR^2 of the spherical nose.

Separation near the spike tip was observed up to a ratio of spike length to spherical nose diameter of 1.78 and a free-stream Reynolds number based on nose diameter of 2.84×10^5, resulting in a value of the foredrag coefficient which was one-third the value with no spike attached. The average heat transfer near the nose of the body was reduced almost to zero by attaching a spike having a ratio of spike length to hemispherical nose diameter of 1.07.

From author's summary

Turbulence

(See also Revs. 2979, 3019, 3020, 3163, 3166, 3171)

3026. Gebelein, H., and Svenson, E., Statistical studies on the turbulent state of motion. Part II. Contributions to dynamics (in English), AFOSR TN 58-43 (ASTIA AD 148 085), 31 pp., Nov. 1957.

Report is the continuation of Technical Note 1 with the same title and by the same authors. The first part concerned kinematics only; this part deals with some contributions to dynamics of turbulence. In § 1 the relationship between the statistical concept of turbulent motion and the classical hydrodynamic equations is discussed. Then § 2 to § 4 bring a systematic account on some dynamical facts of homogeneous turbulence, whereas § 5 and § 6 deal with problems of shear turbulence.

From authors' summary

3027. Loitsianskii, L. G., The hypothesis of localness in the turbulent motion of a viscous fluid (in Russian), *Prikl. Mat. Mekh.* **22,** 5, 600–611, 1958.

Author proposes to consolidate in one general formulation various mixing-length and transfer theories for the mean-velocity profile in turbulent shear flow near a wall. Basic formula for shearing stress is taken as $\tau = \mu(\partial u/\partial y)/(\rho\epsilon/\mu)$ where ϵ is a turbulent viscosity independent of μ. A similar formula is given for heat transfer. The function f is required to be unity at the wall and asymptotically equal to its argument for large argument and is represented more or less arbitrarily by a straight line and an equilateral hyperbola. Various well-known hypotheses for ϵ are discussed; e.g. Prandtl's formula $\epsilon = l^2 \partial u/\partial y$ based on dimensional arguments and Karman's formula $\epsilon = \kappa^2(\partial u/\partial y)^3/(\partial^2 u/\partial y^2)^2$ based on local similarity. Assuming τ = constant, analytic expressions for velocity profile are obtained which are continuous and have continuous first derivatives and which fit experimental data throughout the sublayer and the logarithmic region.

Reviewer believes that author may be too much concerned with form at the expense of substance. The transfer theories in question have been tried and found wanting in many cases, although they have been useful in estimating effects of mass transfer and compressibility. The theories survive because they predict a logarithmic profile. Having obtained a correct result by a wrong argument, it is fundamentally new arguments which are needed rather than variations on the old ones. D. Coles, USA

3028. Frenkiel, F. N., Statistical study of turbulence—spectral functions and correlation coefficients, *NACA TM* 1436, 82 pp. + 5 tables + 93 figs., July 1958.

3029. Paoletti, A., and Vicentini, M., Some examples of turbulent diffusion in liquid metals, *Phys. Fluids* **1,** 5, 453–454 (Letters to the Editor), Sept.-Oct. 1958.

Aerodynamics

(See also Revs. 3000, 3004, 3091, 3108, 3111)

3030. Carafoli, E., and Ionescu, M., General theory of triangular wing with given pressure distribution (in French), *Acad. Repub. Pop. Romine, Rev. Mecan. Appl.* **3,** 2, 5–21, 1958.

Authors discuss the so-called reverse problem which consists in determining the surface form (the warp) of a triangular wing in supersonic flow, the pressure coefficient distribution being given under the form of a higher-order homogeneous polynomial. The cases which define the problem are then presented, pointing out that each of these cases may be reduced to a direct equivalent problem. It follows that the reverse problem may be treated in the same way as the direct problem, namely through the hydrodynamic analogy previously proposed by Carafoli. However, in addition to the singularities used to solve the direct problem, a logarithmic singularity must be introduced at the origin. It is in this way that the solution is obtained. General solutions are given for the thick wing with subsonic leading edges, for the thick wing with one supersonic leading edge, and for the thin wing.

Practical applications include conical motions of the first and second orders. T. Oroveanu, Roumania

3031. Marsden, D. J., Simpson, R. W., and Rainbird, W. J., The flow over delta wings at low speeds with leading edge separation, *Coll. Aero. Cranfield Rep.* 114, 18 pp. + 26 figs., Feb. 1958.

A low-speed investigation of the flow over a 40° apex angle delta wing with sharp leading edges has been made in order to ascertain details of the flow in the viscous region near the leading edge of the suction surface of the wing. A physical picture of the flow was obtained from the surface flow and a smoke technique of flow visualization, combined with detailed measurements of total head, dynamic pressure, flow directions and vortex core positions in the flow above the wing.

Surface pressure distributions were also measured and integrated to give normal force coefficients.

The results of this investigation were compared with those of other experimental investigations and also with various theoretical results. In particular, the normal force coefficients, vortex core positions and attachment line positions were compared with the theoretical results of Mangler and Smith. It was found that:

(1) Secondary vortices of opposite signs to the main vortices exist on the upper surface of the wing outboard of and below the main vortices. These secondary vortices are formed as a result of separation of the boundary layers developing outboard of the top surface attachment lines.

(2) The real flow was found to differ somewhat from the model of Mangler and Smith due to these secondary separations.

(3) The "trailing edge" effect present at subsonic speeds was found to be considerable even at small angles of incidence. The normal force developed by spanwise strips exceeded that predicted by Mangler and Smith near the apex, but fell progressively as the trailing edge was approached. The center of pressure is, however, approximately independent of incidence up to angles of incidence in excess of the semi-apex angle. From authors' summary

3032. Lockwood, R. M., Analytical and experimental investigation of the feasibility of producing static lift by vortex motion, AFOSR TR-58-16 (Hillier Helicopters Advanced Res. Div. Rep. 178; ASTIA AD 148 115), 25 pp., Jan. 1958.

A broad preliminary investigation has been conducted to determine if it is feasible to create static lift in air with small-scale cyclonic vortex motion. A survey of the literature and a variety of experiments with simple equipment were conducted. On the basis of this work a revised description of the fundamentals of cyclonic vortex motion is made, which also suggests some reasons why this motion occurs.

The conclusions are as follows:

1. Cyclonic vortices have been formed between paired suction drains with counterrotating circular flow around them.
2. It should be possible to derive some lift from an arrangement like the preceding one, but magnitudes have not yet been determined.
3. It does not appear to be feasible to induce a cyclonic vortex in air over a single drain which is unenclosed (i.e., completely open to the atmosphere).
4. There is a possibility that half-ring vortices may be created by means of intermittent jets.
5. The passage of the ends of a half-ring vortex across a surface might induce a pressure differential on that surface.

From author's summary

3033. Young, A. D., and Neumark, S., The recovery of an aeroplane from a high speed dive, *Aircr. Engng.* **30**, 357, 332-340, Nov. 1958.

Detailed step-by-step calculations have been made of the recovery with fixed elevator from a high-speed dive for three different aircraft; for these calculations measured wind-tunnel data were used. The aircraft differed markedly in the behavior of their restoring margin $K_m = -(\partial C_m/\partial C_L)_M$. The calculations demonstrated in all cases an initial, rapidly damped, short-period oscillatory phase, a nearly constant value of ρV^2 throughout the recovery, and, subsequent to the initial oscillatory phase, C_m was small. These results enable three different approximate methods for calculating the recovery after the initial oscillatory phase to be developed. The first is applicable where only a rough estimate of the recovery characteristics is required and the value of K_m is about 0.3 or greater; it is very simple and quick to apply. The second is only a little more complicated and is found to give reliable results where K_m is of the order of 0.1 or greater. The third method is the most complicated of the three but is still fairly simple and quick and it can be expected to give reliable results in all cases except where K_m is appreciably negative for a considerable portion of the recovery. In the latter case, however, the aircraft is liable to be unstable and detailed step-by-step calculations or simulator studies are essential for an accurate assessment of the recovery. The main features of the initial oscillatory phase are satisfactorily predicted by Gates' maneuvrability theory if the restoring margin K_m is adequately positive (that is, greater than about 0.005) and if this factor does not vary rapidly with Mach number at that stage. No detailed investigation has been made for aircraft diving at supersonic speeds; however, it seems likely that the general results of this investigation will still apply in such cases. From authors' summary

3034. Miele, A., Flight mechanics and variational problems of a linear type, *J. Aero/Space Sci.* **25**, 9, 581-590, Sept. 1958.

A general analysis is presented of variational problems of linear type. The characteristic of these problems is that the functional forms to be extremized, the differential equations of constraint, and/or the eventual isoperimetric conditions only involve the first power of the derivatives of the unknown functions. For these problems the Legendre-Clebsch condition fails to yield any information on the minimal or maximal nature of the extremal arc; moreover, the Weierstrassian function is zero along a major portion of the Eulerian solution. By the use of a new technique, based on Green's theorem, the aforementioned difficulties can be overcome. Rigorous sufficiency proofs are developed for linear problems of both the simplest type and the isoperimetric type. Several physical problems, associated with the mechanics of flight of either a constant mass or a variable mass vehicle, are treated within the general frame of problems of linear type.

From author's summary

3035. Rosenberg, R. M., On flight trajectories in the neighborhood of a known trajectory, *J. Franklin Inst.* **266**, 2, 109-128, Aug. 1958.

Author shows how to determine the trajectory of an aircraft which flies a trajectory neighboring [nearby] a known trajectory when the effects on the wanted flight program of perturbations in

Mach number, angle of attack, control deflection, atmospheric properties, and so forth are taken into account.

H. A. Stine, USA

3036. Papillo, M. A., Dynamic analysis of the Sea-Master stabilizer position control, ASME Ann. Meet., Nov.-Dec. 1958, New York, N. Y. Pap. 58-A-184, 18 pp.

This paper describes the dynamic characteristics of the Sea-Master stabilizer position control utilizing Laplace transformation and frequency-response techniques. A knowledge of the stabilizer dynamic characteristics is necessary to ensure that the servo position control is dynamically stable and to determine the dynamic characteristics required for overall aircraft stability and control studies. From author's summary

3037. Pritchard, J. L., Analysis of a pneumatic force-balance controller, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-203, 28 pp.

The dynamic characteristics of a three-function pneumatic force-balance controller is determined by computation and then compared with actual performance. Although the three functions are not "pure," author shows that it is possible to describe the device and closely compute the performance analytically. This study does not purport to consider the nonlinear aspect of the controller, but attempts to do a rather thorough analysis on a small signal, nonsaturation basis with the idea that nonlinear studies could be made on analog equipment using the material in this paper as the point of departure. From author's summary

3038. Yff, J., The influence of wing bending and torsion flexibility on the gust response of aeroplanes (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6**, 147-159.

Author considers three degrees of freedom—vertical translation, wing bending, and wing torsion—and shows results for various values of frequency parameters, positions of elastic and inertia axes, density parameter, spanwise mass distribution, and gust gradient distance. By making various simplifying assumptions such as nonviscous incompressible air, strip theory applicability, uniform spanwise gust distribution, straight leading edge, exponential lift functions, author solves the problem on an analog computer for two selected airplanes. It is found that the torsional degree of freedom may have large effects on the wing bending moments, producing large overshoots. Although all the various parameters considered had some effects on the bending moments, the position of the inertia axis appears to be the most important.

B. E. Gatewood, USA

Vibration and Wave Motions in Fluids

(See also Revs. 3079, 3121, 3154)

3039. Dressler, R. F., Unsteady non-linear waves in sloping channels, *Proc. Roy. Soc. Lond.* (*A*) **247**, 1249, 186-198, Sept. 1958.

The unsteady two-dimensional problem of water flow in a straight open channel, as described by the well-known nonlinear hydraulic equations for shallow-water waves, has been solved by Ritter in the simpler case of the horizontal channel, neglecting hydraulic resistance, and in later times approximate solutions were obtained including resistance. For a downward sloping channel, as in the case of unsteady discharge from reservoir, author shows that the problem can be replaced by an associated problem for a horizontal channel, making use of a non-Newtonian reference frame. For the latter, the equations become reducible and thus permit hodograph inversion. The Riemann integration method for the resulting Euler-Poisson equation yields an auxiliary function which is transformable into a Legendre function and then into a complete elliptic integral of the second kind, thus giving the exact solution. The behavior of the solution for the flow of a triangular wedge of water initially at rest and suddenly released is exhibited for convenience in two level-line charts, and representative wave profiles and velocity distributions are displayed.

A. Ghetti, Italy

3040. Prins, J. E., Characteristics of waves generated by a local disturbance, *Trans. Amer. Geophys. Un.* **39**, 5, 865-874, Oct. 1958.

Paper describes a laboratory investigation of the two-dimensional waves generated by an initial local elevation or depression of the water surface. The results are compared with two theories: (a) that of Unoki and Nakano [*Oceanogr. Mag.* **4**, 1953] which treats the two-dimensional case for water of infinite depth, and (b) that of Kranzer and Keller [NYU Inst. Math. Sci., 1 MM-NYU 222, 1955] who consider the three-dimensional problem in water of finite depth.

The shape of the leading wave is dependent on the dimensions of the initial disturbance. In the experiments reported, the leading wave had approximate oscillatory wave characteristics in contrast to solitary wave or bore characteristics. The data and theory are compared in the time-period domain, distance-time domain (phase zero points), for amplitude envelope zero points and wave height. In general the agreement is good for the conditions applicable to each theory. Major discrepancy is between the measured and calculated wave heights, where agreement is poor. In Fig. 3 there appears to be a mix-up or error in the two sets of theoretical curves. H. G. Farmer, Jr., USA

3041. Lawrence, H. R., Wang, C. J., and Reddy, R. B., Variational solution of fuel sloshing modes, *Jet Propulsion* **28**, 11, 729-736, Nov. 1958.

Authors apply the Ritz procedure for calculating the natural frequencies and sloshing modes of a vibrating inviscous fluid with a free surface in a fuel tank. They formulate the linearized problem immediately as a variational principle from Hamilton's equations. Approximate formulas are derived for shallow tanks and very deep tanks. Combining both solutions it is possible to treat the tank with arbitrary depth. Paper gives valuable numerical results for the technically interesting case of a tank with conical bottom. In order to check the accuracy of the Ritz method for the problems in question authors compare the approximate solutions with the known exact solutions for tanks with flat and parabolic bottoms. Using fourth-degree polynomial approximation functions the error in the lowest natural frequency for a flat bottom does not exceed 0.8 per cent. These results show the variational procedure proposed by the authors represents a technically useful method for calculating the sloshing modes, provided that the proper approximation functions are chosen. K. Pohlhausen, USA

Fluid Machinery

(See also Revs. 2873, 2877, 2999, 3182)

3042. Kline, S. J., On the nature of stall, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-170, 15 pp.

The physical data available on the problem of stall are reviewed. The discussion is centered on the problem of flow in passages. The emphasis is placed on systematic visual data showing flow patterns as a function of geometrical parameters. These data lead to a view of stall as a spectrum including three or possibly four major types of flow patterns; these patterns involve both transient and steady elements. A qualitative parameter is formulated which provides a classification for the major types of stall. It is shown that this parameter and its underlying concepts are useful in rationalizing known but previously inexplicable results and in ob-

taining important qualitative predictions. Comparisons between the predictions of boundary-layer theory and the actual systematic stall data of passages are given. From author's summary

3043. Ginsburg, T., Investigation of three-dimensional potential flow through axial cascades of airfoils (in German), *ETH Prom.* no. 2609, 80 pp., 1956.

Detailed report on the results given in the short review of J. Ackeret [*ZAMM* **35**, 360–362, 1955]. Velocities and streamlines of a rectangular broken-off vortex filament are determined. One end of this configuration lies in the axis of two coaxial cylinders, the other end pushes through these two cylinders, and the induced velocities on both cylinders are compensated by source and sink distributions. The induced velocity field at greater distances from the vortex filament is found experimentally by use of an electrolytic tank limited by two coaxial cylinders. By superimposing several such vortex filaments, rectangular broken-off blades of an axial cascade are approximated. In this way author finds the additional three-dimensional velocities.

He has applied this method to a four-bladed turbine cascade of a hub ratio of 0.308 for an elliptical distribution of circulation. A comparison of the resulting blade skeletons with those found by a two-dimensional cascade theory showed a decrease of about 0.3% for the camber/chord ratio of skeletons near the outer cylinder, and near the inner cylinder (hub) an increase of about 0.5%.

F. W. Riegels, Germany

3044. Bugaenko, G. A., Flow round a plane hydrodynamical lattice based on the scheme of the theory of disappearing viscosity (in Russian), *Uch. Zap. Molotovsk. In-ta* **9**, 4, 25–28, 1955; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10245.

3045. Rama Reddy, K., Aerodynamic design of axial flow gas turbine for aircraft propulsion, *J. Instn. Engrs., India* **38**, 11 (part 2), 1045–1073, July 1958.

Analysis given is similar to the method which is generally used for axial-flow compressor. Combining aerodynamic treatment of velocity diagram and thermodynamic consideration to the work done by turbine, velocities and their directions in nozzle- and turbine-cascades are given. As the limiting case, analysis is also made for choked condition in nozzle throat. In blade design, a calculation method is given for constant axial velocity along the blade height. Method of blade section design is also similar to that of A. R. Howell in axial-flow compressor. Numerical examples are given for three-stage turbine.

M. Yamanouchi, Japan

3046. Gofflin, A. P., and Krivosheyin, V. F., Comparison of the experimental and analytical characteristics of existing axial compressors (in Russian), *Energomashinostroyeniye* no. 12, 12–15, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 8845.

A comparison is made between the experimentally obtained characteristic curves of the flow cross section of a number of full-scale, axial compressors, and the analytical data calculated from the characteristic curves of a single-stage model, by a method developed in the Central Institute for Boiler and Turbine Research. The layout of the installation is described, as well as the experimental methods and the evaluation of the experimental results. The experimental and the calculated data agree satisfactorily over a wide range of working conditions of the compressor.

Comparison of the experimental and the calculated data of compressors in conditions approaching pumping indicate that the value of the discharge coefficient determined by calculation from data obtained with a single-stage model is, in practice, the same as for multistage, full-scale machines.

Yu. A. Lashkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3047. Fujie, K., Study of three-dimensional internal flow in impellers of centrifugal blowers with straight-radial blades and logarithmic-spiral blades in radial part only, *Bull. JSME* **1**, 3, 275–282, Aug. 1958.

The flow distribution throughout the passages of rotating impeller has been studied in detail about two types of impellers, one with straight-radial blades and the other with logarithmic-spiral blades, and the results are presented in the form of relative velocity and direction of flow.

In the former case, the measurements are carried out under various numbers of rotation and flow quantities, and those results are compared with the result of two-dimensional potential theory which has been published. From those results, it is understood that the flow in the impeller cannot be conjectured by the theories. The real flow in the experiment, especially when flow quantity is large, passes through the impeller with nearly the same angle as the incidence angle, and the region of the slowest velocity occurs at the negative side in the passage.

In the latter case, the fluid flows comparatively along the blades. The velocity distributions and the direction of flow indicate that the secondary flows in the boundary layer tend to shift the low-energy air toward the negative side within the passage. There is a counter effect at the casing surface apparently caused by leakage flow coming through the blade to casing clearance space. This results in a vortex flow in the passage.

From author's summary

3048. Mayo, A. P., Matrix method for obtaining spanwise moments and deflections of torsionally rigid rotor blades with arbitrary loadings, *NACA TN* 4304, 34 pp. + 10 tables + 9 figs., Aug. 1958.

Method developed seems to be convenient and effective. It is based on step integration and involves only standard matrix procedures. Applicable to hinged, teetering and cantilever blades.

H. Parkus, Austria

3049. Murphy, J. S., and Clutter, D. W., Investigation of the effectiveness of a windmill for improving flow uniformity in a duct, Douglas Aircr. Co. Rep. ES 26393, 31 pp. + 52 figs., Oct. 1957.

Tests have been made to determine the effectiveness of a freely rotating windmill in smoothing out nonuniform duct flow. The action of the windmill is to transfer total head from high-speed regions to low-speed regions. The design of a windmill and the forces on a windmill due to changes in wind speed are discussed. The experimental results show the effect of blade angle and number of blades on the windmill's effectiveness in smoothing out a wide variety of disturbance profiles, both circumferential and radial. The disturbances tested covered a range up to

$$\frac{P_{T_{max}} - P_{T_{ave}}}{q_{ref}} = 1.5$$

The 10-bladed windmill tested was about 50% effective in reducing the disturbances introduced by the distortion devices regardless of the type or amplitude of the disturbances. For comparison, the effectiveness of a 29%-solidity screen in smoothing out the same flow disturbances was investigated. When compared on a basis of effectiveness per unit drag, the windmill devices were about six times better than the screen in smoothing out nonuniform duct flow. From authors' summary

3050. Nazarov, N. T., Fluctuations of level in the screen region of a penstock and means for their elimination (in Russian), *Trudi Mosk. Inzh.-stroit. In-ta* no. 16, 118–123, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6701.

Flow and Flight Test Techniques and Measurements

(See also Revs. 2989, 2998, 3008, 3023, 3025, 3031, 3042, 3073, 3106, 3141, 3161)

Book—3051. Troskolański, A. T., ed., Water metering manual [Poradnik wodomierzowy], Warsaw, Budownictwo i Architektura, 1956, xv + 483 pp.

A practical manual written by A. T. Troskolański, K. Osiński and H. Szymański is for men employed in installation, calibration and maintenance of water meters in water supply nets and in industry. A short introduction on fluid mechanics is followed by methods of hydrometry, types and construction of water meters, arrangements for their calibration, economical and legal aspects, instructions and standards. Numerous tables accompany this perfectly edited and valuable booklet. S. Kolupaila, USA

3052. Smith, P. L., Jr., and Van Winkle, M., Discharge coefficients through perforated plates at Reynolds numbers of 400 to 3000, *AIChE J.* **4,** 3, 266–268, Sept. 1958.

The correlation of Kolodzie and Van Winkle for predicting dry plate orifice coefficients through perforated plates originally covering a Reynolds number range of 2000 to 20,000 has been extended to apply to Reynolds numbers as low as 400. The correlation applies to column diameters ranging from 3 to 15 inches

From authors' summary

3053. Cushing, V., Induction flowmeter, *Rev. Sci. Instrum.* **29,** 8, 692–697, Aug. 1958.

According to Faraday s law of induction, an electric field will be induced in a medium moving relative to a magnetic field. This induced electric field is proportional to the intensity of the magnetic field and to the relative velocity of the moving medium. When applied to media of arbitrary electrical conductivity and dielectric constant, it is seen that any potential difference that arises in connection with the induced electric field is attenuated by the shunting effect of the permittivity of free space. For most media this shunting effect is negligible; for media of extremely low conductivity, however, the effect is appreciable. Finally, the effect of the electrical properties of the containing pipe is investigated.

From author's summary by L. S. G. Kovasznay, USA

3054. Ranz, W. E., Electrolytic methods for measuring water velocities, *AIChE J.* **4,** 3, 338–342, Sept. 1958.

A convection-controlled mass-transfer process, in which the rate of mass transfer results in an electrical signal, should have certain advantages as the working principle for a velocity- and turbulence-measuring device. The velocity can be read at a remote place as a calibrated electrical signal. Compensation for phase shift and amplitude attenuation of a fluctuating signal should be small because the measuring probe would have no capacity for the transferred quantity. In water, such processes are possible whenever electrolysis occurs under conditions of *concentration polarization*, and they exist in relatively uncomplicated form as the *limiting currents* of polarographic analysis. The investigation reported here was intended as a survey and evaluation of electrolytic methods for measuring water velocities.

The series of experiments that was performed showed that a working instrument could be designed on the principle of convection-controlled electrolysis, but that the chemical reactions involved were unreliable for consistent trouble-free results. Practical instruments appear to be possible only after long development and considerable study of chemical mechanisms.

From author's summary

3055. Gotovtsev, V. I., An experiment with the use of pitot tubes for measuring velocity and flow in water-supply pipelines (in Russian), *Vodosnabzhenie i San. Tekhnika* no. 11, 27–32, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9229.

A description is given of an instrument developed by the "VODGEO" Institute for measuring the velocity of the water in supply pipelines. The principle of action of the instrument is the measurement of the differential hydrodynamic pressure in apertures of a cylindrical tube placed in the flow. The instrument needs calibrating. For measuring the mean velocities in steel or cast-iron water-supply pipes, it is recommended to fit the apertures of the measuring tube at 0.24 of the radius from the inner pipe wall. Multiplication of the mean flow velocity by the cross-sectional area of the pipe determines the rate of flow.

If the recording differential manometer is coupled with the instrument, daily records of the flow can be obtained. When used in the Moscow water-supply system, the instrument showed a satisfactory accuracy of 1.5–5.5%. M. E. Faktorovich

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3056. Talbot, L., Koga, T., and Sherman, Pauline M., Hypersonic viscous flow over slender cones, *NACA TN* 4327, 22 pp. + 1 table + 6 figs., Sept. 1958.

Cone surface pressures were measured on a family of 3° semivertex-angle cones (Mach number range $3.7 < M < 5.8$) in University of California hypersonic tunnel. Measurements are compared with various theories including a new one proposed by the authors. Each cone tested had 4.010-inch diameter pressure orifices spaced circumferentially at 90° intervals and connected to a temperature-regulated thermistor manometer sensitive to pressure increments of 0.02 microns of mercury.

Data were in good agreement with previous results on 5° cones in a similar Mach number range and were fairly well predicted by a new method of calculating surface pressures. This method takes into account the interaction between boundary-layer growth and the inviscid-flow field outside of boundary.. Furthermore, all results for both 3° and 5° cones were correlated quite well by means of the viscous-interaction parameter.

R. E. Bolz, USA

3057. Vitale, A. J., Kaegi, E. M., Diaconis, N. S., and Warren, W. R., Results from aerodynamic studies of blunt bodies in hypersonic flows of partially dissociated air, Heat Transf. and Fluid Mech. Inst., Univ. of Calif., Berkeley, Calif., June 1958; 204–215.

A brief review is given of the construction, operation, instrumentation, performance, and some of the experiments in the General Electric Company, Philadelphia, hypersonic shock tunnel.

I. I. Glass, Canada

3058. Martin, W. A., An experimental study of the turbulent boundary layer behind the initial shock wave in a shock tube, *J. Aero/Space Sci.* **25,** 10, 644–652, Oct. 1958.

An experimental study was made of the boundary layer between the shock wave and the entropy discontinuity or contact surface in a conventional shock tube. The boundary-layer temperature and density profiles in this particular region of the shock tube are reversed from those normally encountered in steady channel flow in that the free-stream temperature is greater than the wall temperature.

Shock pressure ratios of 2.75 and 8.0 were used. Density profiles obtained interferometrically were inverted to give temperature profiles. A Crocco temperature-velocity relationship modified for the case of Prandtl number not unity was used to obtain velocity profiles.

The results, consisting of velocity profiles, displacement and momentum thickness and the skin-friction coefficient, were com-

pared with the theoretical predictions of Mirels, *NACA TN* 3712, and, with the exception of the velocity profile parameter, agreement was good. Mirels assumed a 1/7 power law while author's experimental results indicate a 1/5 power law. Transition, as indicated by schlieren and also a thin-film thermometer, occurred very close to the shock wave. Axial pressure gradients were shown to be near zero. The wall temperature, as expected, remained nearly constant at room temperature.

E. K. Parks, USA

3059. Engel, J. N., Experimental measurements of the effects of airplane motions on wing and tail angles of attack of a swept-wing bomber in rough air, *NACA TN* 4307, 15 pp. + 4 tables + 6 figs., Aug. 1958.

Paper presents results of flight tests on a large swept-wing bomber-type airplane in turbulent air. Measurements are made of normal accelerations, pitch angle and pitch velocity, as well as instantaneous angle of attack. Data were recorded over four-minute periods, giving vertical gust velocities and longitudinal motions of the airplane at an altitude of 5000 feet and at a Mach number of 0.63. Test runs were made with the airplane controls in a "stick-free" condition.

Expressions are developed for the instantaneous angle of attack of both the wing and the horizontal tail surface. Analysis of these relationships, based on the observed flight data, is accomplished by application of the power spectra methods commonly used in statistical studies of this type. The effects of vertical velocity appear to be quite small, but the pitching motion tends to increase the gust-induced angle of attack over almost the entire frequency range. The root-mean-square angle of attack is increased about 35%, while the corresponding value for the tail is increased between 50 and 60%.

M. J. Thompson, USA

Thermodynamics

(See also Revs. 2997, 3009, 3082, 3123)

Book—3060. Soo, S. L., Thermodynamics of engineering science, New York, Prentice-Hall, Inc., 1958, xv + 619 pp. $9.50.

Dr. Soo has prepared an interesting and comprehensive text. The principal fault which I find in this work is that it is so broad in scope that it reaches far beyond thermodynamics, and that it is, in fact, a *heat engines* book as well.

There is probably some weakness in the inclusion of the perfect gas law in the first chapter; modern writers prefer to introduce the notion of an engine before discussing the particular fluid medium in use.

In general the illustrations are good. They are simple and clear cut. One exception might be taken to Fig. 4.3, where the absence of shaft coupling between the compressors and turbines might make it more difficult for the student to visualize the fact that shaft work was being done.

It is certainly commendable that the Third Law is included in the chapter on absolute temperature, etc. To the best of my knowledge this is the first time that the Third Law has been mentioned in a mechanical engineering text.

The chapters on the perfect gas and on the properties of a pure substance are very well done and merit close study.

Author has suggested a nice nomenclature in the separation of reactive and nonreactive systems; other workers might do well to emulate this. However, the chapter on heat transfer does not belong in a thermodynamics text. Heat transfer is a field complete in itself: it is a part of the study of heat engines but not properly a part of thermodynamics. The same thing might be said of the chapter on the microscopic theories of matter. Most teachers of thermodynamics introduce some of this material as an aid to the understanding of specific heats, and it is probably welcomed by the student as a bridge between the physics courses in heat and the engineering work on thermodynamics. However, thermodynamics is primarily a macroscopic science.

The chapter on the thermodynamics of fluid flow is competently presented and has good illustrations of practical cases. The section on ideal gas cycles might have been enlarged to include some of the important vapor cycles, with consequent elimination of much of the application material in Chapter 18.

The sections on gas turbines, jet propulsion, refrigeration, steam power plants, and internal combustion engines are competently presented, but belong in a separate text, preferably a book on heat engines.

Dr. Soo is to be congratulated on the fine presentation he has made in several difficult areas. There is a sound exposition of the three basic laws, and the derivation of entropy as a consequence of the Inequality of Clausius is nicely done.

The average student will find in Dr. Soo's book enough material to keep him busy for the last two years in college and to give him a head start in the graduate area. J. H. Potter, USA

3061. Rant, Z., Graphical determination of loss of availability in heat transfer (in German), *Allgemeine Wärmetechnic* **8,** 7, 141–142, 1957.

Method for determining losses in availability due to heat transfer. One can, during the operation of a particular piece of equipment, say a boiler, determine the loss to be anticipated and make the required corrections rapidly. S. Lampert, USA

3062. Vaisman, M. D., The form of certain thermodynamic functions and the critical velocity of wet vapor in the presence of curved phase boundaries, *Soviet Phys.-Tech. Phys.* **3,** 2, 306–317, Nov. 1958. [Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **28,** 2, 333–344, Feb. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.]

From a thermodynamic viewpoint, author analyzes two separate problems concerning a vapor in which small uniform droplets of its liquid phase are suspended. These problems are of interest in connection with steam nozzles, fuel sprays, and vapor-liquid processes which remain entirely in the two-phase region. By using a Clapeyron equation that accounts for the effects of surface tension, author first derives expressions for the difference between the specific entropies, enthalpies, and internal energies of the vapor and liquid at equilibrium. Since these results are actually valid only to first order in the ratio of vapor density to liquid density, reviewer believes that some of the discussion concerning the behavior in the neighborhood of the critical point is questionable. The second problem deals with the critical velocity for one-dimensional varying-area isentropic flow of a vapor-liquid mixture. Requiring phase equilibrium and including the effect of surface tension, author derives an expression for the flow velocity at the point of minimum area in a converging-diverging nozzle or diffuser. Curves of the variation of this critical velocity with temperature are presented for water, mercury, and ammonia vapors with droplets one micron in diameter. It is shown that the calculated corrections to the critical velocity and heat of vaporization for the effect of surface tension are approximately 0.01% in these cases, and would achieve an experimentally observable magnitude (one per cent) only for droplets smaller than 10^{-2} microns.

F. A. Williams, USA

3063. Hsu, S. T., and Leo, B. S., A simple reaction turbine as a solar engine, *Solar Energy* **2,** 3/4, 7–11, July/Oct. 1958.

3064. Meyer, C. A., Silvestri, G. J., and Martin, J. A., Availability balance of steam power plants, *Trans. ASME* **81A** (*J. Engng. Power*) no. 1, 35–42, Jan. 1959.

3065. Amdur, I., and Mason, E. A., Properties of gases at very high temperatures, *Phys. Fluids* **1,** 5, 370–383, Sept.–Oct. 1958.

Approximate methods of obtaining virial coefficient and transport properties of simple pure gases and gas mixtures are developed for the temperature range 1000 to 15,000 K, making use of special forms of intermolecular force potentials. At extreme temperatures the usual form for the force potential functions which depend heavily on attractive forces are unnecessary and inadequate. Data from molecular beam-scattering experiments make possible the accurate estimation of potential functions for the range of repulsive force distances. Such estimates provide the base for calculated second, third and fourth virial coefficients. Similar approximations are applied to determining transport coefficients to the extent these depend on molecular repulsive forces alone. Experimental data are shown to confirm the approximate methods.

N. A. Hall, USA

3066. Shimotake, H., and Thodos, G., Viscosity: Reduced-state correlation for the inert gases, *AIChE J.* **4,** 3, 257–262, Sept. 1958.

A reduced-state viscosity correlation has been constructed from the available data of the inert gases. For the development of this correlation, the fragmentary experimental data for argon were utilized along the lines proposed for thermal conductivities by Owens and Thodos in order to determine the effect of pressure on viscosity. In addition, the only available low-pressure viscosity data for neon and helium have been incorporated in this correlation to produce for the first time the effect of subatmospheric pressures. This correlation covers the range of pressures included between $P_R = 40$ and $P_R = 0.015 \times 10^{-4}$ and extends up to temperatures of $T_R = 100$. It has been found that the effect of subatmospheric pressures on viscosity does not become significant above pressures of 1 mm of mercury. However, at lower pressures, viscosity is found to decrease rapidly, particularly in the regions below absolute pressures of 0.01 mm of mercury.

Viscosities calculated with the reduced-state correlation produce an average over all deviation of 0.93% for neon, argon, krypton, and xenon. In these comparisons the available viscosity data for the gaseous and liquid states of these substances have been included. Deviations of the same order of magnitude are produced for helium in the gaseous state; however, these deviations become excessive for viscosities of helium in the liquid state.

The application of the final reduced-state correlation has been extended to a number of diatomic and polyatomic gases and found to apply well to the diatomic gases only.

From authors' summary

3067. Rivkin, S. L., and Sirota, A. M., Tables of the thermodynamic properties of water and water vapor at pressures up to 400 atm. and temperatures up to 750 °C. (in Russian), *Teploenergetika* **3,** 8, 52–57, Aug. 1956.

3068. Lunc, M., Determination of distribution function of molecular velocities in a stationary gas by a demographic method (in French), *Arch. Mech. Stös.* **9,** 6, 731–737, 1957.

Author attempts to derive the distribution function not by approximate solution of Boltzman equation but by introducing theoretical model where each molecular collision is considered as giving rise to the "birth" or "death" of molecules in an element of a phase space. Hence, presumably, the name of a demographic method. In deriving the distribution function, assumption is made that each collision is "creating" in an element of phase space a local Maxwell distribution in the vicinity of colliding molecules. Explicit mathematical forms of commonly known exponential Maxwell distribution are assumed in the basic "demographic" expression determining general distribution function whose constants are determined from basic conservation laws.

Reviewer believes that the method, despite its pragmatic value, lacks the logical solidity of other methods. This is particularly so because known results of other investigations have to be invoked to enable the calculation of the distribution function instead of deriving it mathematically from basic equations. The identification of various constants appearing in this method with corresponding thermodynamic parameters is accomplished as a result of artificially assuming the validity of local Maxwellian distribution.

B. Zarwyn, USA

3069. Simmons, F. S., and DeBell, A. G., Photographic technique for measuring temperatures in luminous rocket exhaust flames, *J. Opt. Soc. Amer.* **48,** 10, 717–721, Oct. 1958.

Theory is reviewed and technique described for measuring flame temperatures using density of images on photographic film. Two-path optics project image of flame and images of several tungsten filaments at known temperatures on same film. Filament images provide gray scale for measurement of flame temperatures. Method appears practical and good accuracy for luminous flames is reported.

H. R. Hazard, USA

Heat and Mass Transfer

(See also Revs. 2766, 2883, 2994, 2995, 2996, 3007, 3015, 3023, 3061, 3066, 3069, 3151, 3153, 3155, 3158, 3172, 3173)

3070. Robertson, A. F., and Gross, D., An electrical-analog method for transient heat-flow analysis, *J. Res. Nat. Bur. Stands.* **61,** 2, 105–115, Aug. 1958.

An electronic instrument is described which permits solution of transient heat-flow problems by use of direct analogy to electrical networks. The instrument is of the so-called "fast-time" type, simulating the transient involved in times of the order of 10^{-6} that of the thermal prototype. A photoformer type of input-signal generation is used and this, together with a variable frequency master oscillator, permits flexibility of input-signal waveform and time scale. Some applications of the instrument to the field of fire research are described. The discussion of errors includes consideration of those resulting from the lumping of circuit elements.

From authors' summary by V. Paschkis, USA

3071. Lotkin, M., The numerical integration of heat conduction equations, *J. Math. Phys.* **37,** 2, 178–187, July 1958.

Difference analog of one-dimensional transient heat conduction equation is obtained which can be used for various boundary conditions, temperature-dependent thermal properties, time-dependent surface flux and finite composite slabs. Numerical solution is derived for use on high-speed digital computer. Convergence of solution is discussed and an analytical example given.

Discussion of convergence is of special interest; however, the proof is not extended to case of variable thermal conductivity. Assumption of the boundedness of the derivatives (third order) calls, in reviewer's belief, for more elaboration, since such proof (mathematically) is necessary to show convergence for each case considered. For engineering purposes proof given is sufficient.

H. Hurwicz, USA

3072. Smith, J. C., Lind, J. E., Jr., and Lermond, D. S., Shape factors for conductive heat flow, *AIChE J.* **4,** 3, 330–331, Sept. 1958.

Shape factors were obtained for several two-dimensional shapes of practical importance by electrical-analog method. Using results, heat flow between inner and outer isothermal surfaces can be easily calculated for concentric squares and for a circle within a square or rectangle. Results are given in graphical form and are approximated by empirical equations applicable in various regions.

R. G. Deissler, USA

3073. Zakkay, V., Laminar heat-transfer and pressure measurements over blunt-nosed cones at large angle of attack, *J. Aero/Space Sci.* **25,** 12, 794–795 (Readers' Forum), Dec. 1958.

Tests have been conducted at a Mach number of 6, in the PIBAL Hypersonic Facility, to determine the heat-transfer and pressure distributions over a slender blunted cone at angles of attack of 5, 10, and 15°. The stagnation conditions in the tunnel were 615 psia and approximately 1700°R for all tests. The temperature ratio, stagnation to wall, was approximately 2.3. The Reynolds number per inch based on free-stream conditions in the test was 0.31×10^6. The model tested has a spherical nose diameter of 1.0 in., a base diameter of 3.75 in., and a cone half-angle of 20°. The measurements were made at 5 peripheral stations on the model at values of $\psi = 0°$, 45°, 90°, 135°, and 180°; $\psi = 180°$ locates the windward side.

In this note the experimental results at a 15° angle of attack are presented. From author's summary

3074. Roberts, L., A theoretical study of stagnation-point ablation, *NACA TN* 4392, 22 pp. + 6 figs., Sept. 1958.

Author treats the subject of heat transfer from a high-velocity air stream to a subliming solid at the stagnation point. The system of interest is one in which the subliming solid acts as a heat barrier or insulator for some airborne object. Insulation is effected because of the heat capacity of the solid, its latent heat, and because the injection of the vapors into the boundary layer impedes the heat transfer between the air and solid. Author analyzes this complex case of heat and mass transfer near the stagnation point of a two-dimensional body. A number of simplifications including integral techniques and a linear velocity distribution are employed. He derives an expression for the rate of sublimation of the solid. The results reveal quantitatively the importance of high specific heat and low thermal conductivity to the effectiveness of the solid material. T. J. Connolly, USA

3075. Schwartz, E. W., Heat transfer to water coolant in capillary tubes for the liquid, mixed, and vapor phases, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-234, 15 pp.

Stainless-steel capillary tubes, heated electrically, were employed to obtain local heat-transfer coefficients, based upon bulk fluid properties, with and without a coolant-phase change. The coolant was distilled water which was forced into the tubes; the internal diameters of the tubes were 0.007, 0.017, and 0.025 in. The coolant flowed from the exit section of any given tube to the atmosphere in the form of heated water, quality steam, or superheated steam, depending upon the heat flux and coolant flow rate. Satisfactory correlations with the theoretical and empirical equations derived by Graetz, Drew, Hottel, and McAdams were obtained for heating of water flowing inside the capillary tubes at constant mass-flow rates. However, no correlation was observed with these equations when a coolant-phase change occurred within the tubes. For coolant phase-changing conditions, empirical correlations of local heat-transfer coefficients that included the liquid, mixed, and vapor phases of the coolant were obtained as functions of local coolant enthalpy, coolant mass velocity, and capillary diameter. From author's summary

3076. Al-Arabi, M., Study of existing data for heating of air and water in turbulent flow in inside tubes, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-298, 16 pp.

The data available for heating air and water in turbulent flow inside tubes have been studied. The correlations made have shown that the usually accepted equations of Dittus and Boelter, Colburn and Seider and Tate, do not well represent the results for a "tube of infinite length." Modified equations are suggested.

The water data had to be divided into two groups, a group for "low temperature heating" and a group for "high temperature heating." The two groups do not follow the same line and are represented by different equations. From author's summary

3077. Ambrose, T. W., and Knudsen, J. G., Local shell-side heat transfer coefficients in baffled tubular heat exchangers, *AIChE J.* **4,** 3, 332–337, Sept. 1958.

Local heat-transfer coefficients were determined on shell side of a baffled tubular heat exchanger. Baffles were so placed as to tend to cause crossflow over the tubes between each pair of baffles. Baffle spacing and tube spacing were varied, but volumetric flow rate was held constant. High heat-transfer coefficients were observed near entrance and at points where small clearance occurred between tubes and baffles. When crossflow occurred over tubes, heat-transfer coefficient was highest on upstream side of tubes and a minimum on downstream side.

Average Nusselt number for shell side was calculated and found to agree fairly well with values obtained by other investigators. Addition of baffles caused Nusselt number and pressure drop to increase at about the same rate as the number of baffles increased from two to ten. Increasing tube spacing at constant flow rate increased average heat-transfer coefficient in spite of lower local velocities for the wide spacing. This was explained by the larger effect of turbulent wakes behind the tubes for the wider spacings.
R. G. Deissler, USA

3078. Liepmann, H. W., A simple derivation of Lighthill's heat transfer formula, *J. Fluid Mech.* **3,** 4, 357–360, Jan. 1958.

Beginning with the energy integral equation of a laminar boundary layer, author deduces a heat-transfer equation valid for nonuniform temperature distribution and nonzero pressure gradients. Agreement with Lighthill's result is shown to be good. For the case of laminar flow near separation, author's deduction is compared to the Falkner-Skan solution for just-separating flow, and agreement is shown to be good. For the case of high Mach number flows, author indicates the conditions under which recovery enthalpy may replace h_∞. C. R. Mischke, USA

3079. Drazin, P. G., The stability of a shear layer in an unbounded heterogeneous inviscid fluid, *J. Fluid Mech.* **4,** 2, 214–224, June 1958.

This paper considers the stabilizing effect of density stratification on the horizontal shear layer between two parallel streams of uniform velocities. A simple continuous velocity distribution, $U = V \tanh(y/d)$, is used to represent the laminar shear layer. The density of the fluid is assumed to vary as $\exp(-\beta y)$, y being the vertical coordinate, with a small total change in density across the shear layer. The fluid is unbounded and is assumed to be inviscid, incompressible and under the action of gravity.

By the methods of hydrodynamic stability theory it is shown that a disturbance of small amplitude and wave-number α is neutrally stable if the Richardson number, defined as $J = g\beta d^2/V^2$, has the value $\alpha^2 d^2(1 - \alpha^2 d^2)$, and the form of the neutral disturbance is obtained. It follows that the critical Richardson number is 1/4, so that the flow is stable if $J > 1/4$. The relation between these results and Goldstein's derivation of the same critical Richardson number for a flow with discontinuous velocity and density gradients is discussed.
From author's summary by C. C. Lin, USA

3080. Jackson, T. W., Harrison, W. B., and Boteler, W. C., Free convection, forced convection, and acoustic vibrations in a constant temperature vertical tube, *ASME Trans.* **81C** (*J. Heat Transf.*), no. 1, 68–74, Feb. 1959.

Variation, with sound pressure level, of heat-transfer coefficients was measured under combined natural and forced convection in vertical tube.

Driver speaker created variable intensity standing wave in tube. Air flow through tube caused condensation of steam in surrounding jacket. Condensate was measured to determine heat-transfer rate.

Nusselt modulus ranged from 17–50, Graetz modulus from 40–1633 and Grashoff-Prandtl D/L modulus from 0.97 to 12.6×10^5.

Below noise level of about 118 db no increase in transfer rates were detectable, although natural convection was in evidence. Transfer rates increased considerably above 118 db despite apparent absence of natural convection. No conclusion as to effect of frequency was possible.

Reviewer agrees with authors that more work upon heat transfer under acoustic conditions is needed. A study under conditions of "white noise" would be of immediate practical aeronautic interest where heat-transfer problems are associated with noise from boundary layers, jets and intakes. D. B. Leason, England

3081. Beckwith, I. E., Similar solutions for the compressible boundary layer on a yawed cylinder with transpiration cooling, *NACA TN* 4345, 49 pp. + 6 tables + 11 figs., Sept. 1958.

Prandtl's equations for a compressible boundary layer on an infinite cylinder in yaw are solved. Ejection of the same gas as flowing by the cylinder through the cylinder wall is considered. Specific heat, Prandtl number, and wall temperature are postulated constant. Through Stewartson's transformation, the three-dimensional problem is converted into a two-dimensional one, and by the postulate that in this plane the velocity outside the boundary layer is proportional to a power of the distance x, similarity in the boundary-layer profiles is established. 200 numerical solutions have been obtained on an electronic computer IBM 704 for two classes of problems: (1) small M number, (2) arbitrary M, but $Pr = 1$ and $\rho\mu$ = constant. The results indicate that transpiration cooling reduces skin friction and heat transfer by large amounts, with the largest reductions occurring at small yaw angles and for a Prandtl number 1. Comparison of solutions computed with Sutherland's viscosity law with solutions using a linear viscosity temperature relation indicate that, for a highly cooled surface, heat-transfer coefficients from both solutions may differ up to 150%. The values of the heat-transfer parameter at the stagnation point of a body of revolution obtained in this paper with Sutherland's viscosity relation and with a Prandtl number 0.7 agree closely with results of Faw and Riddell for a real dissociating gas.

E. R. G. Eckert, USA

3082. Godridge, A. M., Thurlow, G. G., and Wallis, J., A method of studying the influence of flame characteristics on heat transfer in furnaces, *J. Inst. Fuel* **31,** 214, 491–505, Nov. 1958.

Small-scale experiments are conducted in order to evaluate the heat flow through the furnace walls. The apparatus developed is an insulated combustion chamber, inside of which takes the form of vertical cylinder, 5-in. diam. The results are given of measurements of the heat flow through the chamber wall, temperature, gas analysis and radiation characteristics of the flames. The flames used are laminar diffusion flames, turbulent diffusion flames, and premixed flames of city gas or methane. It is shown that the radiant heat transfer to the chamber wall is not affected markedly by the characteristics of the flames, because of the self-compensating effect in flames which is caused by the interplay of flame temperature and its emissivity. Authors say that these results can be used in predicting the heat transfer through the furnace walls in full-scale plants, since the combustion mechanism within the flame in the combustion chamber is similar to that in the furnaces as seen in carbon particle concentration.

S. Kumagai, Japan

3083. Czarnecki, J. T., Performance of experimental solar water heaters in Australia, *Solar Energy* **2,** 3/4, 2–6, July/Oct. 1958.

3084. Ward, G. T., Evidence for the need of a cheap simple solar radiation recorder, *Solar Energy* **2,** 3/4, 34–36, July/Oct. 1958.

3085. Bressler, R., Experimental investigation of the evaporation of thin liquid fluids (in German), *Z VDI* **100,** 15, 630–638, May 1958.

First part deals with observations on falling films on vertical flat plates with boiling occurring in the film. Curves are given for heat load and apparent coefficient for water and a 10% glycerine solution as a function of temperature difference and flow rate. Second part deals with heat transfer to evaporating liquids in a vertical thin film evaporator with rotating blades. Effects of rotation speed, type of blade, feed rate, and temperature difference are given for water and for carbon tetrachloride. Optimum conditions for each product are indicated as heat transfer increases initially with feed rate until the entire surface is wetted and thereafter decreases. Due to bubble action, heat-transfer coefficients are higher than predicted by Nussett film theory.

A. C. Mueller, USA

3086. Frossling, N., Evaporation, heat transfer, and velocity distribution in two-dimensional and rotationally symmetrical laminar boundary-layer flow, *NACA TM* 1432, 32 pp. + 6 tables, Feb. 1958.

3087. Duff, A. D., Jr., and Wilson, E. E., A heat exchanger design for heavy water reactor service, *Canad. J. Chem. Engng.* **36,** 5, 203–206, Oct. 1958.

The volume of heavy water required for a power reactor plant using this moderator has an important influence on investment. Likewise, the cost of leakage justifies extraordinary containment measures. A heat-exchanger design is described which satisfies these requirements, as well as those imposed by the radiation field in which the equipment must operate.

From authors' summary

3088. Mucskai, L., and Soliom, I., Calculation of hydraulic resistance in the heat exchangers (in Hungarian), *Energia es Atomtechnika* **11,** 7/8, 452–456, July/Aug. 1958.

Authors give practical formulas for pressure drop across heat exchangers including baffles, valves and other components.

L. S. G. Kovasznay, USA

3089. Gould, L. A., Approximation of the dynamic behavior of heat exchangers (in English), *Ingenioren* **66,** 30, 825–830, Dec. 1957.

After showing complexity of analytical treatment by two simple examples, circuits for R-C network computers are introduced which can be used for the solution of problems at hand. Reviewer believes that assumption (c) should read: Thermal resistance of exchanger tubes in axial direction is infinite (instead of negligible). Also reference to Paschkis and Hlinka, *Trans. N. Y. Academy of Science* Ser. II, **19,** no. 8, 1957 is overlooked; this describes the same circuits. Since Gould refers to dissertation 1953, work may have proceeded simultaneously. V. Paschkis, USA

3090. Levin, B. I., and Dumer, A. B., Estimation of shell-side temperature in the construction of heat-exchanging apparatus (in Russian), *Energomashinostroenie* no. 3, 26–27, Mar. 1956.

Combustion

(See also Revs. 3069, 3070)

3091. Emmons, H. W., Combustion—an aeronautical science, *J. Aero/Space Sci.* **25,** 12, 730–741, Dec. 1958.

The basic sciences which are essential to an understanding of combustion are briefly presented and their present limitations are noted. These limitations imply limitations in our knowledge of

combustion processes and, thus, indicate areas needing further research. From author's summary

3092. Fine, B., The flashback of laminar and turbulent burner flames at reduced pressure, *Combustion and Flame* **2,** 3, 253–266, Sept. 1958.

The effects of reduced pressure on critical boundary velocity gradient for flashback were studied for laminar and turbulent burner flames of hydrogen and propane with several oxygen-nitrogen, oxygen-argon and oxygen-helium mixtures. The apparatus is described and graphs are drawn of pressure versus velocity gradient. The flame reaction orders based on flashback are in general agreement with other works based upon quenching and burning velocity. Comparison was also made between laminar and turbulent flames.

Reviewer feels this is an interesting study but that it could be related more closely to previous work in this field.

J. H. Davidson, USA

3093. Eschenback, R. C., and Agnew, J. T., Use of the constant volume bomb technique of measuring burning velocity, *Combustion and Flame* **2,** 3, 273–285, Sept. 1958.

The computation of burning velocities from constant-volume bomb data is developed from first principles. It is shown that the degree of completeness of combustion can not be determined with accuracy from bomb data. This is important in computing burning velocity. The apparatus used is described and the results of observed burning velocities of methane-oxygen mixtures at pressures of from 0.1 to 2.0 atmospheres are compared with calculated values. The results are in fair agreement, J. H. Davidson, USA

3094. Chertock, G., Pressure buildup due to burning in a vented chamber, *David W. Taylor Mod. Basin Rep.* 1048, 13 pp., July 1957.

An analysis similar to that for the classical tank blow-down problem is made in which gas generation and chemical energy release are also considered. Assumptions are made of perfect gas behavior, instantaneous thermodynamic equilibrium, and no external heat transfer. The equations are solved for the case of constant burning rate, gas specific heat ratios, molecular weight, and afterburning (oxidation of rich products by air in chamber). It is shown that the peak pressure in the chamber is independent of chamber volume and depends only on the ratio of vent area to burning rate. The time at which the peak pressure is reached varies directly with the chamber volume.

No experimental data are reported although it is said that the analysis predicts the time to reach peak pressure within a 30% error for one constant burning rate solid propellant.

R. H. Eustis, USA

3095. Mironov, V. D., Systems for automatic control of combustions with the use of oxygen meters (in Russian), *Teploenergetika* **3,** 11, 25–29, Nov. 1956.

3096. Perry, C. W., High energy fuels for jet propulsion engines, *Canad. J. Chem. Engng.* **36,** 6, 247–251, Dec. 1958.

3097. Barshtein, I. K., and Rubin, M. M., Operating characteristics for shaft pulverizer furnace with cyclone burners (in Russian), *Energomashinostroenie* no. 9, 1–5, Sept. 1956.

Prime Movers and Propulsion Devices

(See Revs. 3011, 3045, 3063, 3064, 3096, 3118)

Magneto-fluid-dynamics

(See also Rev. 3053)

3098. Lin, C. C., Note on a class of exact solutions in magneto-hydrodynamics (in English), *Arch. Rational Mech. Analysis* **1,** 5, 391–395, Aug. 1958.

Paper shows how the partial differential equations governing the magnetohydrodynamic flow of an incompressible fluid can be simplified for a particular class of solutions. For these solutions the velocity and magnetic fields, and the pressure gradient are allowed to vary in a general manner with time and one space coordinate, but can only vary in a linear way with the other two space coordinates. A simple nonmagnetic example of this type of motion is steady laminar flow about a rotating disk, where the velocity components take on a variation in the direction normal to the plate, but have only linear variations with radius. Author states that some specific solutions to this set of magnetohydrodynamic equations are being obtained and will be published later.

R. Siegel, USA

3099. Stix, T. H., Generation and thermalization of plasma waves, *Phys. Fluids* **1,** 4, 308–317, July–Aug. 1958.

The generation of hydromagnetic and ion cyclotron waves by an induction coil is considered. Rapid thermalization of transverse plasma waves occurs when appreciable numbers of ions stream through the periodic perturbation with velocities such that in their own rest frames these ions "feel" the perturbation at their own cyclotron frequency. This effect, termed cyclotron damping, makes an efficient plasma heating scheme for thermonuclear reactors possible. From author's summary D. Ter Haar, England

3100. Buneman, O., Instability, turbulence and conductivity in current-carrying plasma, *Phys. Rev. Letters* **1,** 1, 8–9, July 1958.

Author investigates the effects of collective Coulomb interactions in fully ionized plasma. He concludes that small angle collisions cause instabilities which grow so rapidly that relative motions of ions and electrons are continually damped down by conversion of directed energy into random fluctuation energy. The implications of this effect on gas conductivity and plasma radiation are suggested. Speculations relative to explanation of Langmuir's paradox and deleterious effects in devices in which electrons are channeled through ions, or vice versa, are stated.

C. M. Crain, USA

3101. Lykoudis, P. S., On a class of magnetic laminar boundary layers, Heat Transf. and Fluid Mech. Inst., Univ. of Calif., Berkeley, Calif., June 1958, 176–186.

In the present work the general problem of wedge-type flows was investigated; it was shown that general "similarity" solutions exist for the boundary layer if the intensity of the magnetic field acting perpendicularly to the direction of flow varies according to a power law with respect to the distance from the inward stagnation point. In the case of two-dimensional stagnation flow, similarity solutions were obtained when the magnetic field remains constant. The results of this paper—which apply for any fluid as long as it is electrically conducting (such as molten metals)—were particularly investigated for the important case of hypersonic stagnation flow taking into account also dissociation effects.

R. J. Mindak, USA

3102. Finkelstein, D., Sawyer, G. A., and Stratton, T. F., Supersonic motion of vacuum spark plasmas along magnetic fields, *Phys. Fluids* **1,** 3, 188–192, May–June 1958.

Studies of plasmas produced by sparks in vacuum are reported. The observations of principal interest concern the speed with which such plasmas leave the spark. The conclusions about plasma speeds are that they are approximately ten times greater than the

thermal speeds associated with spark temperature, varying between 2×10^6 and 2×10^7 cm/sec and, in the range observed, the velocities are approximately independent of the spark parameters. It is suggested that the pinch effect may be the mechanism of plasma acceleration.

From authors' summary by C. M. Crain, USA

3103. Bhatnagar, P. L., The equilibrium of a self-gravitating incompressible fluid sphere with magnetic field, *J. Indian Inst. Sci., Section A and B* **40,** 2, 50–73, Apr. 1958.

Equations of equilibrium of a self-gravitating incompressible fluid and electromagnetic Maxwell's equations, in the steady case, are used to study the problem of magnetic fields that can prevail in an axisymmetric configuration. A new class of axisymmetric magnetic fields is characterized and the following special types are studied: force-free, poloidal, toroidal, and combination of toroidal and poloidal fields. The paper relates to the problem of magnetic stars. G. Sestini, Italy

3104. Covert, E. E., On some fundamentals in magneto-fluid-mechanics, Mass. Inst. Technol., Naval Supersonic Lab., Tech. Rep. 247, 298 pp., Mar. 1958.

The basic equations of magneto-fluid-mechanics are derived from classical kinetic theory for a gas consisting of neutral particles, positive particles (ions) and electrons. Included are the equations of conservation of mass and momentum for each type of particle, an energy equation, the Maxwell equations of electrodynamics, and suitable state equations. The basic equations are normalized and the resulting dimensionless parameters are discussed briefly.

Formulas for the fluid properties are presented, and a summary of the values of these properties is given.

Some elementary solutions are given to illustrate the nature of magneto-fluid interactions.

The problem of adding energy to a gas by magneto-fluid mechanical means is discussed and it is concluded that these means are practical only at high power densities (i.e., 700 kw/ft^2 ~ 5×10^6 BTU/sec-ft^2). A device which absorbs such power densities and generates a plasma is discussed theoretically and some preliminary experimental results from this device are given.

From author's summary

3105. Groenig, H., and Weymann, H. D., Measurements of the boundary layer thickness and relaxation of ionization behind strong shock waves with a new capacitive probe, AFOSR TN 58-387 (ASTIA AD 154 294), 17 pp. + 9 figs., Feb. 1958.

Report deals with the measurements of the thickness of the boundary layer with a capacity probe. This probe inserted flush into the wall of the shock tube and thus avoiding any disturbances in the flow is sensitive to the thickness of the boundary layer when the gas in the undisturbed flow is ionized. The experimental results for argon at Mach numbers between 5 and 10 show the usefulness of the probe for measuring the thickness of the boundary layer, the relaxation time of ionization and the coefficient of diffusion. The experiments were carried out in argon because high Mach numbers could be achieved in argon even with a small shock tube. From authors' summary

Aeroelasticity

(See also Rev. 3038)

3106. Molyneux, W. G., Experimental model techniques and equipment for flutter investigations, *Aircr. Engng.* **30,** 357, 324–329, Nov. 1958.

An outline is given of the uses of flutter models as an aid to the designer in the avoidance of flutter. Details are given of the different types and methods of construction that are used for flutter models and of the various test facilities that are available for high-speed and low-speed tests.

The procedure followed in the U.K. for flutter clearance of the full-scale aircraft is described, and the value of the electronic flutter simulator in this field is discussed.

From author's summary

3107. Crisp, J. D. C., Equivalent configurations in flutter analysis, *Aero/Space Engng.* **17,** 11, 55–61, Nov. 1958.

Paper describes a method for deriving from a system of flutter equations with a known solution, new systems of equations for which the flutter speeds and frequencies are the same. Multiplying factors, like the scaling factors used in analog computing, are introduced into the rows and columns of the characteristic determinant. In certain cases these factors can be interpreted as realistic changes in the real parameters of the system and so "equivalent configurations" are derived. Paper illustrates the technique in relation to wing-aileron flutter. Method is clearly of value in initial design and in later modifications required to overcome troubles experienced in operation. W. S. Hemp, England

3108. Mollö-Christensen, E., Utilization of experimental results in flutter analysis, *J. Aero/Space Sci.* **25,** 10, 635–643, Oct. 1958.

Author prefaces this paper with a brief analytic discussion of the equations of motion of a flexible wing in an air stream, listing the assumptions, equations of motion, and two methods of approximation of the deflection amplitude. Methods for evaluating changes in flutter characteristics due to changes in structural and aerodynamical parameters are given. The precision of information obtained from tests is considered and the resulting accuracy of the flutter prediction is discussed. Methods are applied to the determination of aerodynamic forces from test data.

A. H. Hausrath, USA

3109. Stepanov, R. D., On the flutter of cylindrical shells and panels moving in a flow of gas, *NACA TM* 1438, 15 pp. + 2 tables + 2 figs., Sept. 1958.

Paper is a translation of "O Flattere Tsilindricheskikh Obolochek i Panelei Dvizhushchikhsia V Potoke Gaza," *Prikl. Mat. Mekh.* **21,** 5, 1957.

Stability of infinite cylindrical shells and panels using Vlasov's (Donnell's) equation and of cylindrical shells of medium length using Gol'denveizer's equation is investigated for high Mach numbers. Air forces according to Ilyushin ("Piston theory") are employed throughout. Explicit solutions are obtained for the minimum critical speeds, agreeing with the results of Leonard and Hedgepeth, and Miles, for high Mach numbers. For shells of medium length, a method is developed to investigate the stability of unperturbed motion for arbitrary boundary conditions. Comparison with the results of a variational procedure is used as the basis for application of the procedure to the more general theory of shallow shells. Sample results are included. H. M. Voss, USA

3110. Lehrian, Doris E., Calculation of flutter derivatives for wings of general plan-form, *Aero. Res. Counc. Lond., Rep. Mem.* 2961, 10 pp. + 9 tables + 3 figs., 1958.

The vortex-lattice method of calculating flutter derivatives presented in this note is an extension to higher frequencies of the work on stability derivatives reported in *Rep. & Mem.* 2922. The method is a modified form of the scheme outlined in *Rep. & Mem.* 2470 and is suggested as an alternative to the latter method since it gives a simpler routine calculation for wings of general plan-form. Derivatives are calculated for the following wings describing plunging and pitching oscillations:

(*a*) Delta wings of aspect ratio $A = 1.2$ and 3 and with a taper ratio 1/7

(*b*) Arrowhead wing of aspect ratio 1.32 with a taper 7/18 and angle of sweep of 63.4 deg at quarter-chord.

The results for the delta wing $A = 1.2$ and the arrowhead wing are compared with values of the pitching derivatives obtained in low-speed tests; those for the delta wing $A = 3$ with the values calculated in *Rep. & Mem.* 2841. The comparison indicates that the present method gives reasonable accuracy for low-aspect-ratio wings in incompressible flow; the method may be sufficiently reliable for use with the equivalent wing theory suggested in *Rep. & Mem.* 2855 for the calculation of flutter derivatives in compressible subsonic flow. From author's summary

3111. Macovsky, M. S., Vortex-induced vibration studies, *David W. Taylor Mod. Basin Rep.* 1190, 15 pp., July 1958.

The progress at the David Taylor Model Basin of basic studies concerning the mechanism of vortex-induced vibration of a circular cylinder is reviewed. Techniques for measuring lift and drag forces and for analyzing wake structure are presented. Measurements of the maximum alternating lift force coefficients in the Reynolds range $10^4 < R < 10^5$ are given. It is shown that these values are comparable to the drag coefficients at the low end of this Reynolds range, but diminish rapidly near 10^5. Breakdown of the two-dimensionality of the flow is presumed to be the explanation, judging from earlier flow studies.

From author's summary

Aeronautics

(See Rev. 3059)

Astronautics

(See also Revs. 2788, 2789, 3034, 3035)

3112. Dobrowolski, A., Satellite orbit perturbations under a continuous radial thrust of small magnitude, *Jet Propulsion* **28,** 10, 687–689 (Tech. Notes), Oct. 1958.

Author studies orbit of rocket in take-off from satellite in circular orbit, under constant radial thrust (from earth's center), of subcritical magnitude. The perturbed trajectory suffers temporary departure from the satellite orbit, with maximum radial displacement never surpassing in length the radius of the original orbit.

A. A. Bennett, USA

3113. Miele, A., On the brachistochronic thrust program for a rocket powered missile traveling in an isothermal medium, *Jet Propulsion* **28,** 10, 675–684, Oct. 1958.

Paper studies nearly vertical rocket motion, assuming constant gravity, isothermal atmosphere, and negligible induced drag with respect to zero-lift drag, by methods of the calculus of variations, to minimize the time required to reach a given point. The boundary-value problem is handled for various initial and final values of altitude, Mach number and mass.

Using appropriate hypotheses, closed form solutions are obtained for three sorts of arcs, showing many graphs illustrating their fitting at corner points to yield a minimum. Starting from rest, the optimum path includes usually an initial sub-arc with maximum engine output, an intermediate sub-arc with diminishing thrust, and a terminal coasting sub-arc. This article is a condensation of a Douglas Aircraft SM Report in press at the listed date.

A. A. Bennett, USA

3114. Singer, S. F., and Wentworth, R. C., A method for calculating impact points of ballistic rockets: convenient representations, *Jet Propulsion* **28,** 10, 684–687 (Tech. Notes), Oct. 1958.

The elliptic trajectory of a coasting rocket referred to an inertial frame fixed with respect to the stars and neglecting air friction was studied in an earlier paper by these authors, determining the impact point on the rotating earth. Previous results are here given a dimensionless representation. Included are corrected results to handle nonequatorial launchings. Paper gives graphs for angular range, peak altitude, and time of flight for a succession of angles of departure. A. A. Bennett, USA

3115. Turnacliff, R. D., and Hartnett, J. P., Generalized trajectories for free-falling bodies of high drag, *Jet Propulsion* **28,** 4, 263–266, Apr. 1958.

Authors present a graphical method for calculating velocity versus height for high-drag bodies in fall through the atmosphere. The coordinate system is so chosen and the parameters and boundary conditions are so introduced that generalized graphs can be constructed from the equation of motion. Thus the trajectory for a given body as characterized by its drag-to-weight ratio, initial velocity, initial altitude, and angle of descent can be obtained by inspection. H. A. Stine, USA

3116. Harris, I., and Jastrow, R., A short program for satellite orbit prediction, Rep. NRL Progress, Feb. 1958, 1–8. (PB131 635).

Brief description of equations used to fit a modified ellipse to observed satellite data. Effects of drag are included in numerical integration. Secular motion of line of nodes due to earth's oblateness is included. Similar motion of line of apsides is ignored.

W. A. Mersman, USA

3117. Lieberman, P., Simulation of free flight structural characteristics by captive missile. I. Computer analysis, *Jet Propulsion* **28,** 9, 622–624 (Tech. Notes), Sept. 1958.

3118. Herrick, S., and Baker, R. M. L., Jr., Recent advances in astrodynamics, *Jet Propulsion* **28,** 10, 649–653, Oct. 1958. (Survey Article).

Acoustics

(See also Rev. 3080)

3119. Gazarian, Iu. L., On producing a sound pulse of specified shape by means of a piezoelectric plate, *Soviet Phys.—Acoustics* **4,** 1, 31–34, Oct. 1958. [Translation of *Akust. Zh.* **4,** 1, 33–36, Jan./Mar. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.].

The one-dimensional problem of generating such an acoustic pulse is treated mathematically by a generalization of the d'Alembert solution of the differential equation of wave motion through the inclusion of a piezoelectric medium. The production of rectangular pulses of duration $n \cdot 2l/c$ is discussed in some detail, where $2l$ is the thickness of the plate, c the speed of propagation within the plate, and n a positive integer. R. Heller, USA

3120. Pridmore-Brown, D. C., Sound propagation in a fluid flowing through an attenuating duct, *J. Fluid Mech.* **4,** 4, 393–406, Aug. 1958.

A study is made of the propagation of sound in both a constant gradient shear flow and a turbulent shear flow above a flat surface. Curves are presented showing how, in the case of downstream propagation, the flow gradient tends to channel the sound energy into a narrow layer next to the wall. These results are used in estimating the effect of a flow on the attenuation of sound in a duct with absorbing side walls. R. C. Binder, USA

3121. Gol'dberg, Z. A., On the propagation of plane waves of finite amplitude, *Soviet Phys.—Acoustics* **3,** 4, 340–347, July 1958. [Translation of *Akust. Zh.* **3,** 4, 322–328, Oct./Dec. 1957 by Amer. Inst. Phys., Inc., New York, N. Y.].

Finite amplitude acoustic waves are investigated in a second-order approximation. A criterion is studied for generation of discontinuities in a viscous thermoconductive medium. The absorption coefficient is computed. The paper continues two former papers of same author. F. E. Borgnis, Germany

3122. Tanaka, S., Some aspects of ultrasonic attenuation in common metals (in English), *Rep. Inst. High Speed Mech., Tohoku Univ.* **9**, 81/90, 149–158, 1958.

Ultrasonic attenuation may be measured by observing, with fairly sophisticated circuitry, decay in amplitude of a multiply-reflected pulse. In common metals, attenuation is observed to vary directly with frequency until the wavelength approaches grain size, when a sharp increase in attenuation occurs. In the linearly-dependent frequency region author proposes, as a simplification, to measure voltage rise at resonance across a piezoelectric driving transducer having resonant frequency above range used. Calibration is established by comparison with known attenuation of mild steel and aluminum. Method is rapid, and results show satisfactory correlation with values obtained by pulse attenuation. Theory is presented to support experiment. V. Salmon, USA

3123. Bogorodskii, V. V., The elastic characteristics of ice, *Soviet Phys.—Acoustics* **4**, 1, 17–21, Oct. 1958. [Translation of *Akust. Zh.* **4**, 1, 19–23, Jan./Mar. 1958 by Amer. Inst. Phys., New York, N. Y.].

Author describes ultrasonic pulse technique for measurement of Young's modulus and shear modulus of samples of Arctic ice cut at various depths. Resonant frequency of transducer crystals was 500 kc/s. Transit times of pulses in ice are compared with times in standard liquid, and error in measurement of velocity is estimated as 0.6%. Values of Young's modulus, shear modulus, and hence Poisson's ratio, are given for fresh-water ice in temperature range 0–25 C and with ice densities 0.902 – 0.890. Arctic ice was cut from various depths of "permaice" and pack ice, and measurements of constants are given. Linear relation between velocity of ultrasonic waves and temperature of the arctic ice was found.

K. W. Hillier, England

3124. Corcos, G. M., Some measurements bearing on the principle of operation of jet silencing devices, *Douglas Aicr. Co. Rep.* SM-23114, 23 pp. + 48 figs., Mar. 1958.

Present report describes an attempt to explain in simple terms how ejectors, corrugated nozzles and multiple nozzles modify the turbulent mixing of a jet so as to generate less aerodynamic noise. Starting from a few facts which result from dimensional analysis, from simple analytical considerations or from experiments, a hypothesis is formulated which can be summarized as follows.

Ejectors, corrugated and multiple nozzles generate less aerodynamic noise than corresponding plain nozzles do mainly insofar as they decrease the turbulence levels in the mixing region. This is accomplished by accelerating the ambient air before it is mixed with the jet. Thus a sheath of flowing air decreases the lateral jump in the mean axial velocity which is responsible for the turbulence level in the mixing region.

Experiments at low speed with corrugated nozzles and ejectors are then reported. Mean velocity profiles and turbulence surveys were obtained. The results are in good agreement with the expectations and provide strong support for the hypothesis.

A few secondary observations are made concerning the change of scale caused by corrugated nozzles. From author's summary

Micromeritics

(See also Revs. 2879, 2977, 3085, 3138, 3169)

3125. Lester, R. H., Subsieve particle size measurements on porcelain materials, *Bull. Amer. Ceram. Soc.* **37**, 3, 129–134, Mar. 1958.

A full description of a sedimentation method is given for analysis of subsieve particle-size distribution down to O.I. μ. The method used is a cumulative one of gravitational and centrifugal sedimentation with hygrometer as a measuring instrument. Stokes's law and modification of this law for centrifugal sedimentation are quoted. The idea of the equivalent time of gravitational and centrifugal sedimentation is introduced. The working details of equipment, test procedure and calibration of hygrometer are stated with details of nomographs for quick calculation of results. The corrections for hygrometer reading are given, but the influence of temperature on viscosity of sedimentation medium is not mentioned. Some actual results on clays are given as graphs of particle-size distribution. The method seems to be practical and short. W. de O'Byrn, England

3126. Gayle, J. B., Lacey, O. L., and Gary, J. H., Mixing of solids—Chi square as a criterion, *Indust. Engng. Chem.* **50**, 9, 1279–1282, Sept. 1958.

Paper suggests "chi square" as a convenient measure of mixedness for granular mixtures with more than two components. This criterion, widely used in other statistical applications, is defined as $\chi^2 \equiv \sum_i \frac{1}{E_i}(O_i - E_i)^2$ where O_i is the observed number of particles of i^{th} type in a sample and E_i is the "expected number," based on the relative number in the total batch.

The procedure is illustrated by experiments on a 3-component case. S. Corrsin, USA

3127. Itaya, S., Takenaka, T., and Sanjo, S., A study of flow properties of paper stock suspension, *Bull. JSME* **1**, 3, 282–285, Aug. 1958.

Authors measured the pipe friction losses up to consistency of about 6%, using groundwood pulp suspensions which have comparatively stable properties for flow, with brass pipes 23.3, 36.6, and 48.8 mm in diameter and galvanized gas pipes 1", 1½", and 2".

As for results, the pipe friction coefficients λ versus a new dimensionless number: $N = 8\frac{\rho v^2}{\tau_w}$ (N is flow number, ρ density, v mean velocity in pipe and τ_w shearing stress on pipe wall) which corresponds to Reynolds number in the case of water, coinciding well on the line of $\lambda = 64/N$.

Moreover, authors give the calculation formulas of pipe friction losses which are more accurate than previous ones.

From authors' summary

3128. Eresenkov, N. I., Calculations for horizontal settling tanks of small dimensions for use in collecting water from canals, rivers and ponds (in Russian), *Sb. Tr. Novocberkas. Inzh.-melior. In-ta* **5**, 89–96, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 538.

3129. Levi, I. I., Erosion in the "under" water of river hydronodes (in Russian), *Trudi Leningr. Politekhn. In-ta* no. 178, 31–50, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5558.

3130. Batin, N. A., The calculation of branching pipelines (in Russian), *Sb. Nauch. Tr. Belorus. Lesotekhn. In-ta* no. 8, 149–164, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6646.

3131. Grishanin, K. V., The dissipation of energy in flows carrying suspended precipitates (in Russian), *Trudi Leningrad In-ta, Inzh. Vodn. Transp.* no. 23, 46–52, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9189.

The energy dissipated in unit time by a level flow carrying suspended particles is determined as the difference between the force of gravity acting on a prism delimited in the flow, and the frictional

force acting on the lower edge thereof, representing the delimited prism as a layer of liquid included between the free surface of the flow and a lower plane parallel thereto.

In application to the flow of a pure liquid, i.e. without suspended particles, the expressions (19)-(22), quoted by author, have been given earlier by G. I. Taylor, *Proc. Roy. Soc. Lond.* (*A*) **151**, 873, 459-460, 1935. M. A. Dement'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3132. Popov, B. A., The simulation of solids in a wave flow (in Russian), *Trudi In-ta Okeanologii, Akad. Nauk SSSR* no. 9, 173-182, 1954; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 8959.

A survey is presented of the known fundamental criteria for the flow of an incompressible fluid, and an analysis of the similarity conditions in the modelling of the action of a wave flow on small, solid particles, the characteristic dimension of which is perceptibly less than the wavelength. G. I. Barenblatt

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3133. Rabinovich, B. V., The theoretical principles of the construction of slag traps (slag skimmers) (in Russian), *Liteynoe Proiz-vo* no. 7, 15-20, 1954; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9007.

The conditions are determined which govern the floating of light (slag) particles contained in an immobile, or variously mobile, heavy liquid (molten metal).

From the analysis made, a method is developed by which it is possible to float light particles by the shortest path; the principles of the action of existing forms of slag traps or skimmers are investigated, and new, more effective forms of construction are suggested. I. E. Idel'chik

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3134. Ranz, W. E., Some experiments on orifice sprays, *Canad. J. Chem. Engng.* **36**, 4, 175-181, Aug. 1958.

This is a report on a systematically planned experimental investigation based on theoretical considerations, mainly of dimensional analysis and of the principle of similitude.

New approaches to studies of spray systems were demonstrated by a series of experiments using liquid jets of mercury and of carbon tetrachloride spraying in water. Using water (instead of air) as the ambient medium is a novel method of slowing down the spray phenomena and thus making it easier to observe and photograph them. Attention was focused on those conditions in which the stresses causing break-up arose from the inertia of the surroundings, and in which the induced motion of the surroundings controlled the characteristics of the spray zone in front of the orifice. Experiments and analysis involved principle of balanced stresses, dispersion angle, motion of induced phase, development of spray zone, and drop size. Impact stresses and shear stresses acting between the ambient and the disperse phase are expressed mathematically in physical terms. Photographs of mercury spray and carbon tetrachloride spray in water are shown. Experimental equipment is illustrated and described; photomicrographs of sprays are shown, with size-distribution charts derived from them.

K. J. DeJuhasz, Germany

3135. Williamson, K. I., and Taylor, W. B., The analysis of particle counts by the spray-drop method, *Brit. J. Appl. Phys.* **9**, 7, 264-267, July 1958.

The spray-drop method is used in electron microscopy to determine the concentration of particles in an unknown suspension. A suspension of polystyrene latex spheres in known concentration is used as reference. It is mixed in known proportions with the unknown suspension, sprayed as a fine mist, collected on electron microscope specimen holder, and then examined under the microscope. Complete drops are photographed and the number of particles and the number of latex spheres in each whole drop are tabulated. The number of particles and the number of latex spheres do not bear the same ratio in all drops, owing to sampling errors or to bad mixing. The errors of this method are critically examined by statistical mathematics, and an improved method is proposed whereby the sampling errors can be mitigated. A test is included to check the presence of variations in the data due to causes other than purely random ones, e.g., inadequate mixing. The test is applied to artificial, i.e. made up, sets of data to illustrate its usefulness.

This paper deals with "randomness," "inherent variation," "induced variation" and other refined concepts of statistics, as applied to suspensions, in particular of biological nature; its value is enhanced by the extensive listing of basic source books on statistics. K. J. DeJuhasz, Germany

3136. Mercier, R., An aerodynamic phenomena characterized by hysteresis (in French), *C. R. Acad. Sci., Paris* **246**, 5, 698-701, Feb. 1958.

The aerodynamic drag coefficient of very small spheres has been investigated experimentally; it was found to be a function of the initial Reynolds number of the sphere, and not of the instantaneous, changing values of it. Author finds that the drag coefficient varies inversely with the 5/8 power of the Reynolds number; actually, however, the 5/8 is a mean value, and the true value fluctuates between 1/2 and 2. Author interprets his findings as the "heredity" of the aerodynamic phenomenon. He refers to the paper of Ingebo [Drag coefficients for droplets and solid spheres in clouds accelerating in air streams, *NACA TN* 3762, 1956; AMR **10** (1957), Rev. 770] dealing with a related subject.

K. J. DeJuhasz, Germany

3137. Fujimoto, T., The performance of the hydrocyclone as a collecting unit, *Bull. JSME* **1**, 2, 162-170, June 1958.

On the hypothesis that the collection characteristics of the hydrocyclone will depend upon the design of the unit and operating conditions, performance tests were carried out using an experimental unit. Paper gives the results of the work, including some suggestions with respect to collection efficiency.

The influence of the following factors on the collection efficiency η_c was investigated: (1) Feed inlet velocity v_i; (2) diameter of vortex finder D_o, underflow nozzle D_u and cylindrical portion D; (3) dimension of inlet nozzle $\sqrt{bb}$; (4) effective height of cyclone H_0; (5) inserted length of vortex finder S; (6) types of feeding; (7) pulp density δ_f and particle size of feed slurries d.

In addition to the above, equations are given expressing the following two theoretical formulas: (1) Critical feed inlet velocity corresponding to the maximum collection efficiency $\eta_{0(max)}$, and (2) collection efficiency η_0.

From author's summary

3138. Fujimoto, T., Experiments on the pressure drop in hydrocyclone, *Bull. JSME* **1**, 3, 305-311, Aug. 1958.

The pressure drop in the hydrocyclone is an important factor along with its performance, since the pump used for the cyclone must be selected according to the pressure drop and also because the amount of necessary energy is dependent upon the pressure drop and the quantity of liquid.

Author has measured the differences in pressure between the inlet and the overflow pipes under various operating conditions.

The influences of the following factors on the pressure drop were investigated: (1) Feed inlet velocity v_i; (2) diameters of vortex finder D_o; underflow nozzle D_u and cylindrical portion D; (3) dimension of inlet nozzle $\sqrt{bb}$; (4) height of cyclone H; (5) inserted length of vortex finder S; (6) types of feeding; and (7) pulp density of feed slurries δ_f.

From the results of his experiments, author presents the equation to represent the pressure drop through the cyclone.

From author's summary

3139. Fujimoto, T., The performance of the hydrocyclone as a thickener, *Bull. JSME* **1**, 3, 312–320, Aug. 1958.

On the hypothesis that the thickening characteristics of the hydrocyclone will depend upon the dimensions of the unit and operating conditions, performance tests were carried out using an experiment unit.

This paper gives the results of the work, including some suggestions with respect to the thickening ratio δ_u/δ_f, i.e. the underflow density δ_u divided by the feed density δ_f.

The influences of the following factors upon the thickening ratio δ_u/δ_f were investigated: (1) Diameters of vortex finder D_0, underflow nozzle D_u and cylindrical portion D; (2) feed inlet velocity v_i; (3) dimension of inlet nozzle $\sqrt{bb}$; (4) height of cyclone H; (5) inserted length of vortex finder S; (6) types of feeding pipe; (7) pulp density δ_f and particle size of feed slurries d.

In addition to the above, author expresses in equations the following two experimental formulas: (1) Flow ratio G_u/G_0, i.e. the underflow quantity G_u divided by the overflow quantity G_0; (2) thickening ratio δ_u/δ_f.

From author's summary

3140. Fujimoto, T., The performance of the hydrocyclone as a classifier, *Bull. JSME* **1**, 3, 321–328, Aug. 1958.

In the light of the fact that the hydrocyclone is essentially a classifier, performance tests were carried out using an experimental unit. In order to evaluate the results of classification, Tromp's distribution curve method was adopted in relation to particle size.

This paper gives the results of the work, including some suggestions with respect to the cut size d_T; in the afore-mentioned distribution curve, d_T is the particle size at 50% partition of the underflow discharge.

The influences of the following factors upon the cut size d_T were investigated: (1) Feed inlet velocity v_i; (2) diameters of vortex finder D_0, underflow nozzle D_u and cylindrical portion D; (3) dimension of inlet nozzle $\sqrt{bb}$; (4) height of cyclone H; (5) inserted length of vortex finder S; (6) pulp density δ_f and specific gravity of feed slurries s.

In addition to the above, the author gives an equation to express cut size.

From author's summary

3141. Ranz, W. E., and Katz, E. J., A test method for evaluating mist and dust collection equipment, Penn. State Univ., Dept. Mech. Engng., TR 2, 27 pp., July 1958.

Report describes an experimental test stand developed for the evaluation of the performance of mist and dust collection equipment. It discusses a procedure for measuring impaction efficiencies and certain other performance characteristics of collectors, and it shows how data can be obtained for a scientific analysis of such equipment.

A sampling system was developed which measures the concentration of various sizes of mist before and after the collector that is being tested. By separating the sample into size fractions, the device is capable of distinguishing impaction efficiencies for different ranges of particle size as well as over-all efficiencies.

Readers are encouraged to consider especially those aspects related to the possible development of a standard test method.

From authors' summary

Porous Media

(See also Revs. 3151, 3153)

3142. Tsitskishvili, A. R., A semi-inverse method in the theory of filtration from curvilinear channels (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 4, 129–133, Apr. 1957.

Generalising the method developed by Lavrentiev [see Lavrentiev, M. A., and Shabat, B. V., "Metodi teorii funktsii kompleksnogo peremennogo," Gostekhizdat, Moscow, 1951], paper presents solutions for channels of any shape and for dammed and undammed water level as well. The formula giving the function of flow

$$\chi(w) = cw - \frac{1}{\pi}\int_{-\infty}^{+\infty} \frac{f(t)\,dt}{t-w} \qquad \left(\begin{matrix}\chi = \chi_1 + i\chi_2 \\ w = u + iv\end{matrix}\right)$$

contains the real constant $0 \leqslant c < \infty$; if $c = 0$, there is no damming; if $c = 1$, we get Lavrentiev's case. Author makes following suppositions: the water table is a plane; the filtration takes place in a homogenous granular medium; there is no capillarity, and, on the free surface, evaporation. Taking for $f(x)$ functions which are continuous and have finite limits, solutions for channels of various shapes can be deduced. If $c = 0$, the method gives exact solutions for any shape.

A. Kezdi and G. Petrasovits, Hungary

3143. Razumova-Sretenskaya, V. N., Some axisymmetric motions of a gas in a layer of coal (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 6, 119–125, June 1957.

Investigation of the effect of borings driven at right angles to the free surface of a coal layer. The gas thus relieved moves along the bore-hole; in the first approximation, author considers the gas as incompressible. For compressible fluids corrections have to be used. The first part gives the solution for an axisymmetric motion, where the gas enters on a very limited part of the surface of the bore hole (point-like source). The quantity of gas entering the bore hole could be evaluated. The second part solves the case of a source uniformly distributed along the line of the bore hole.

The method can be used advantageously also for treating the problem of water motion in granular material.

A. Kezdi and G. Petrasovits, Hungary

3144. Lipayev, Yu. A., An investigation into the rate of gas evolution from spherical coal lumps in relation to their radius (in Russian), *Trudi In-ta Gorn. dela Akad. Nauk SSSR* **3**, 193–199, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6953.

Assuming that in the case of instantaneous fragmentation the "average" fragment will be spherical in shape, and assuming an initial gas pressure of 10 kg/cm² in the seam, author writes and solves the corresponding filtration equations.

Further, a numerical calculation is made for the weight of flow of gas from a fragment of a coal seam with a radius of 0.25 m, on the assumption that this sphere is in turn fragmented into 10 spheres of identical radius.

As could be anticipated, author's calculations show that the weight of flow of a gas from the coal decreases with time more rapidly in the case when the coal fragment is broken up into smaller pieces.

K. P. Stanyukovich

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3145. Matveenko, T. I., On unsteady filtration in one and two layers (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 6, 126–129, June 1957.

Solutions for filtration toward a well in layered soils; in the first case, the layer around the well is homogeneous, but underneath the well there is a layer of weak permeability. On the free upper surface, there is infiltration with constant intensity. Boundary and initial values thus given, author deduces the differential equation in polar coordinates, then applies the Laplace transform, getting an equation of the Bessel-type, which has been solved.

The same method has been used for solving unsteady filtration for a layered system when, besides the lower layer with weak permeability, there is an intermediate layer of the same permeability. No numerical evaluation is given.

A. Kezdi and G. Petrasovits, Hungary

3146. Tixier, M. P., Porosity balance verifies water saturation determined from logs, *J. Petr. Technol.* **10,** 7, 161–169, July 1958.

In several log interpretation methods, water saturation is evaluated by use of the ratio of the readings of a short-spacing resistivity device and a long-spacing resistivity device plus information on the mud filtrate and connate water resistivities, which is often derivable from the SP. These methods are valid over a certain range of conditions, usually specified by moderate invasion and R_{xo} greater than R_t. Since these methods involve no explicit evaluation of the formation factor F, the saturation so found may be used in the standard Archie equation to derive a computed formation factor which, as a check, may be compared with the formation factor known from other independent measurements. Discrepancies in the two values of formation factor generally indicate that the ratio method is not within its range of applicability. If the computed F is too low, the corresponding S_w is too low; if the computed F is too great, the corresponding S_w is too great. By means of this "porosity balance" check, and some knowledge of the probable conditions of invasion, the interpretation can often be improved.

The porosity balance check is discussed for the cases of the Induction-Electrical Log Interpretation Method, the Rocky Mountain Method, and the R_{xo}/R_t Method. For the first method, a discussion is also given for the case of shaly sands.

From author's summary

3147. Babalyan, G. A., and Mukharinskaya, I. A., The extrusion from a porous medium of one liquid by another (in Russian), *Tr. Azerb. N.-i. In-ta po Dobyche Nefti* no. 2, 205–214, 1955; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10694.

3148. Melik-Asslanov, L. S., and Avanessov, V. T., The part played by the intermediate zone in the expulsion of petroleum by water in a porous medium (in Russian), *Trudi Azerb. N.-i. In-ta po Dobyche Nefti* no. 3, 61–87, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9207.

For the purpose of establishing the dimensions of the intermediate wave, i.e. the region carrying both petroleum and water, in both static and dynamic states, three experiments were made on the displacement of petroleum by water from samples of an artificial, porous medium (length 3 meters, gas permeability 1.1 D'Arcy units), containing residual water. The change in water saturation along the length of the sample was determined by the variation in electrical conductivity. Experimental data have been obtained which characterise the yield of petroleum in a waterless period, as well as the total dimensions of the intermediate zone, and, from the variation in electrical conductivity, the distribution of water-saturation along the sample at the beginning and end of the experiment.

L. V. Lyutin

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3149. Tsibulsky, G. P., Solution of the problem of controlling the motion of oil-bearing star contours (in Russian), *Izv. Kazansk. Fil. Akad. Nauk SSSR, Ser. Fiz.-matem. i Tekhn. Nauk* no. 9, 35–47, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Re. 9205.

Paper is a generalization of the results of researches on controlling the motion of the oil-bearing contour, made by G. S. Salekhov for star contours for the case that the law of motion of the oil-bearing contour is a given parameter, which enables both star-shaped and non-star-shaped contours to be investigated.

An approximate solution of the problem is constructed with the help of the following assumptions: the stratum is horizontal, homogeneous, isotropic, and of constant thickness; the system is of a unique liquid; the stratum is under hydraulic pressure; a linear law of filtration applies.

A method is established for selecting the law of motion of the oil-bearing contour in the form of a parameter, for known initial and final positions of the contour according to the rate of withdrawal of the oil which would ensure uniform contraction of the whole contour without the formation of patches and areas of water intrusion (flooding).

A specimen calculation is examined in which the initial contour of the oil-bearing region is star-shaped and the final contour non-star-shaped.

P.F. Fil'chakov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3150. Pilatovsky, V. P., The problem of the exploitation of oval-shaped oil basins. Determination of the yields and bore pressures in elliptical batteries (in Russian), *Trudi Vses. Neftegaz. N.-i. In-ta* no. 8, 114–141, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9203.

Geophysics, Hydrology, Oceanography, Meteorology

(See also Revs. 2788, 2896, 2909, 2964, 2965, 2986, 3063, 3083, 3084, 3144)

3151. Philip, J. R., Evaporation, and moisture and heat fields in the soil, *J. Meteor.* **14,** 4, 354–366, Aug. 1957.

This paper is a study of the mechanisms of vapor and liquid transfer of water in unsaturated soils, and their influence on evaporation from a bare soil surface. Vapor pressure, liquid concentration, and temperature gradients are treated. Quantities appearing in an energy balance at the surface are considered. Parameters of importance in several analytical models are discussed, and numerical values are included. Literature references are ample, and the paper is recommended as a good exposition of interest both to soil physicists and micrometeorologists.

D. M. Vestal, Jr., USA

3152. Dawance, M. G., Measurement and effect of vibration on houses and industrial buildings (in French), *Ann. Inst. Tech. Bât. Trav. Publics* **10,** 115/116, 714–728, July/Aug. 1957 (Supplement).

A general discussion is presented of seismic and vibration measuring equipment, the frequency and damping effects of vibration propagation in the earth, magnitude scales for seismic vibrations, and the effect of vibrations on buildings.

A. H. Hausrath, USA

3153. Andreae, C., Temperature forecasting for subterranean regions (in French), *Ann. Ponts. Chauss.* **128,** 1, 37–85, Jan./Feb. 1958.

Studies were made at the request of "Electricite de France" when the Isere-Arc gallery was built in Savoy; recently in connection with the new Arc-Isere Project, the author investigated the problem of subterranean temperatures. Empirical forecasts of such temperatures, based on observations, are somewhat vague and their practical results inadequate. In 1906 J. Koenisberger and E. Thoma proposed a method based on Fourier's analytical theory of heat. Author attempts to perfect the theory and adapt it to engineering requirements. Forecast is based on formulas deduced from the Fourier theory, the soil temperature, geological formation, conductivity of rocks, and hydrological conditions.

From author's summary by S. Lampert, USA

3154. Cartwright, D. E., On estimating the mean energy of sea waves from the highest waves in a record, *Proc. Roy. Soc. Lond.* (*A*) **247,** 1248, 22–43, Sept. 1958.

Analysis is made of the probability distribution of the highest of N waves, assuming that successive waves are uncorrelated. Accurate computations are made by numerical integration, and

asymptotic formulas are developed for expectation and standard error. Similar analyses are effected for second and third highest waves, whose sampling errors are somewhat lower. The consequence of mutual correlation of adjacent waves is also discussed after making certain simplifying assumptions. Results are applied to an actual record containing some 10,000 ocean waves, measurements being in good agreement with theory.

G. Power, England

3155. Ichiye, T., On convective circulation and density distribution in a zonally uniform ocean, *Oceanogr. Mag.* **10,** 1, 97–136, June 1958.

Calculations of density and velocity fields in a highly parameterized model of convection on a rotating reference frame are made. The model most closely resembles one discussed earlier by Fofonoff, but the author does not compare his and Fofonoff's results in a physically instructive way, nor is he able to make a meaningful comparison to real oceanic structure because the purely zonal model is too remote from the meridionally bounded basins that actually exist, and whose dynamics is essentially different. For example, the north-south component of flow in Ichiye's model is essentially frictional, whereas in the real ocean it is predominantly geostrophic. W. H. Munk, USA

3156. Timofeef, M. P., Transformation of air above water basins (in Russian), *Meteorol. i Gidrologiya* no. 6, 26–29, 1955; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8067.

An analysis is carried out of the solution of the equation of turbulent diffusion of humidity q in the stationary case $u \frac{\partial q}{\partial x} = \frac{\partial}{\partial z}\left(k \frac{\partial q}{\partial z}\right)$ (where x, z are the horizontal and vertical coordinates, $u = u(z)$ and $k = k(z)$ are the wind velocity and coefficient of turbulent exchange—stepped functions of height) with simple originals on x and boundary conditions.

E. M. Dobryshman

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3157. Dzhordzhio, V. A., Stream flow (in Russian), *Meteorol. i Gidrologiya* no. 6, 49–60, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8066.

An extensive range of material on the investigation of stream flow is systematized in this paper. Author determines stream flow as a narrow zone of violent winds of long duration, observed in the upper troposphere and in the tropopause zone, structurally connected with the planetary altitudinal frontal zone. The basic properties of stream flows are indicated and their classification is described, this being constructed on the basis of the classification of the planetary altitude frontal zones. Author considers last the question of the orographic influence on stream flows and also gives dimensions of stream flows and indicates their basic parameters (horizontal, vertical shear of the wind, and so forth). Models are given to show the circulation around the stream, and the distribution of temperature and humidity in the stream flow zone is indicated. An investigation is also made on problems concerning clouds, settling and strong turbulence (aeroplane bumping) in the upper troposphere and stratosphere under a clear sky, connected with stream flows. In conclusion the connection is investigated between stream flows with fronts and cyclonic activities.

K. G. Abramovich

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3158. Tsikunov, V. A., One method for determining the coefficient of turbulent heat conductivity in the upper layer of the sea (in Russian), *Trudi Okeanogr. In-ta* no. 33, 45, 80–91, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5754.

3159. Buell, C. E., The correlation between wind and height on an isobaric surface, *J. Meteor.* **15,** 3, 309–316, June 1958.

Since the two-point correlations of winds on an isobaric surface approximate those expected from a two-dimensional isotropic turbulence, it follows that in a flow that is geostrophic the two-point correlations of wind and height must have a specific functional form. The form of the two-point correlation function for wind and height is predicted from relations between this function and the correlation functions for the two-point correlations of wind and the two-point correlations of height. The theoretical predictions are compared with observational data and found to be reasonably well realized. The two-point correlation function for wind and height is applied to height and wind observations at a point for the estimation of these quantities at a distance of several hundred nautical miles. From author's summary by R. O. Reid, USA

Book—3160. Bibliography of hydrology, for the year 1956 [Hydrologická bibliografie za rok 1956] (Czech, also in Russian, German, and English), Praha, Hydraulic Research Inst., 1958, 219 pp. (Paperbound)

Hydraulic Research Institute of Czechoslovakia resumes with this issue the regular publication of hydrological bibliography issued under auspices of The International Association of Scientific Hydrology for 10 years (1933–1942) and discontinued after loss of independence. This reappearance is to be particularly welcomed, because Czechoslovakia actually initiated that important enterprise in 1932, and all free nations are continuing scientific cooperation. Bibliographic index for 1956 contains 579 items. Waterways and hydraulic engineering are covered in addition to hydrology. All titles are translated into Russian, English and German; short annotations are added in Czech. Translation could be better, particularly the Russian. It would be very appropriate if bibliography for the missing 12 years could be compiled.

S. Kolupaila, USA

Book—3161. Ihrig, D. (edited by), Report on the activities of the Research Institute for Water Resources in 1956 [Beszámoló a Vízgazdálkodási Tudományos Kutató Intézet 1956 évi Munkájáról], Budapest, Müszaki Könyvkiadó, 1957, 296 pp. (Paperbound)

D. Ihrig, Director of the Hungarian Research Institute for Water Resources, reports on the first five years of its activity, which continues the 72 years of tradition of the Hungarian Hydrographic Service, the oldest in Europe. During these five years the members of the Institute published 114 scientific papers. Series of articles are included into this volume. Some titles follow: Filling in incomplete hydrologic data, by B. Csermák; Graphical determination of land evaporation, by K. Szesztay; Flood heights due to debacle, by W. Lászlóffy; Possible storage investigations, by T. Puskás; Theoretical backgrounds for construction of curves for flood forecasts, by I. Zsuffa; Selection of a water meter for irrigation, by Ö. Sztarosolszky; New investigations of runoff and infiltration in carstic regions, by H. Kessler; Hungarian net of groundwater observation wells and their observations, by I. Diossy and K. Ubell; Water balance in a sandy plain between Danube and Tissa River, by K. Ubell; Seepage losses from irrigation canals, by G. Szilágyi; Water balance in irrigated rice fields, by I. Vágás; Five reports on water quality investigations; Approximate correlation with two variables, by J. Bogárdi; Recording gage for the hydraulic laboratory, by K. Fazekas; Investigations of several hydrometric devices for clogging prevention, by K. Fazekas, O. Györke and O. Haszpra; Water-stage fluctuations in the new Western main irrigation canal, L. Ivocsics; Combined sluice and lock in the Western main irrigation canal, by E. Varrók; Testing of constructions of the Tiszalök irrigation system, by L. Muszkalay.

Short summaries in one of four foreign languages close this valuable contribution to the progress of science.

S. Kolupaila, USA

3162. Bullen, N. I., The sampling errors of atmospheric turbulence measurements, *Aero. Res. Counc. Lond. Rep. Mem.* 3063, 7 pp. + 4 tables + 4 figs., 1958.

3163. Mochizuki, M., and Sakagami, J., Lagrangian measurement of small-scale atmospheric turbulence by floating fine particles, *Ochanomizu Univ., Tokyo, Nat. Sci. Rep.* **8,** 2, 67–79, Nov. 1957.

Fibrous clusters for flow tracers were formed by subliming metaldehyde crystals by a pulsed heating from a coil of nichrome wire. The 5-mm clusters were discharged 1 m from the ground in a large unoccupied area on dark breezy nights. Illumination of particles and marking poles was provided by strobiscopic light sources. Photographs were taken by two pairs of cameras, covering overlapping areas; each pair gave a stereoptic effect. Particle position was determined by a reprojection technique; for a large program this could probably be done faster by photographic-plate measurement and reduction of data with a digital computer.

Data were analyzed to obtain the Lagrangian correlation coefficients, standard deviation of particle positions, and the energy spectrum. Representative tracks of particles relative to time average mean displacement are also shown. Insufficient data were obtained to deduce any significant conclusions as to turbulence near the ground, but continuation of the work is indicated.

Reviewer has done similar work using puff-ball spores in small turbulent systems. The analysis is tedious, but such experimental information is necessary to complement hot-wire methods and theoretical analysis. A. A. Putnam, USA

3164. Shekhter, Ya. N., The structure of wind currents (in Russian), *Trudi Vses. N.-i. In-ta Mekhan. S.-Kh.* **22,** 46–60, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9179.

The structure of wind currents was investigated by means of low-inertia anemometers with damped receivers, as constructed by D. Ya. Surazhsky (Thesis, 1953), whose accuracy in the range of wind velocities between 1.5–60 mps was 5.5%, and the time constant 0.03 sec, as well as by means of electro-anemometers and contact instruments. It has been found that the degree of gustiness of a wind current at the measuring point can be very considerable—for an average wind velocity over 5 mps, gusts up to 7.3 mps, and in the maximum 15.2 mps, are observed, with accelerations in individual cases exceeding 4–5 m/sec/sec. At the same time, the amplitudes and phases of gusts at points in the flow distant 10–50 meters from each other do not coincide so that the degree of gustiness of a wind current averaged over the flow cross section is considerably less; for an area of 15-meters diameter, the accelerations are 0.3–0.4 m/sec/sec.

A curve is given for the coefficient of wind-gustiness, $k = v_{max}/v_{mean}$ for different values of the mean wind velocity, v_{mean} from the records of a single anemometer, two anemometers 40 meters apart, and three anemometers arranged on a circle of 12 meters diameter. With increasing value of v_{mean}, the value of this coefficient decreases (for the three anemometers, from 1.5 at $v_{mean} = 5$ mps, to 1.2 at $v_{mean} = 15$ mps). Curves are also given for the distribution of the periods of reduced wind velocity ("lulls") and the mean wind velocities during such lulls. It is found that for wind velocities averaged over 30–40 minutes, of 7.75–8.25 mps (8 mps being the rated speed of the wind motor), about 80% of the lulls do not exceed 120 secs in duration, and their wind speeds do not fall below 7.15 mps.

The results obtained are suitable for use in calculating the overload forces on wind motors, as well as the capacity of buffer storage batteries for maintaining the wind motor output during lulls. A. S. Monin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3165. Mertsalov, A. N., Qualitative determination of well regulated vertical motions of air in the baric field (in Russian), *Trudi Tsentr. In-ta Prognosov* no. 45 (72), 59–64, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8071.

Using the work of B. D. Uspenskii, author proposes the correlation

$$D = -\frac{1}{l}\left(\frac{\delta\Omega}{\delta t} + w\frac{\partial\Omega}{\partial z}\right) = -\frac{1}{l}\frac{d\Omega}{dt} \qquad [1]$$

where $D = \partial u/\partial x + \partial r/\partial y$ is the horizontal wind velocity divergence; x, y, z are rectangular coordinates, while axes x and y are placed in the investigated horizontal plane (at the given level), and axis z is directed upwards, u,u, v, w are corresponding components of wind velocity; $l = 2w \sin\varphi$ in the parameter of Coriolis (w is the angular velocity of the earth's rotation, φ is the geographical latitude); $\Omega = \partial v/\partial x - \partial u/\partial y$ is the vertical component of the vortex velocity at a given level; $\delta\Omega/\delta t$ is the change of vortex velocity with time, referred to the moving particle, taking into account its transfer from one level to another. Assuming the motion to be geostro-physical, author gives formula [1] in the form of:

$$D = \frac{b}{l^2}\left(\frac{\delta\Lambda H}{\delta t} + w\frac{\partial\Lambda H}{\partial z}\right) = -\frac{b}{l^2}\frac{d\Lambda H}{dt} \qquad [2]$$

Here b is some constant (approximate), H is the absolute geopotential, $\Lambda = \partial^2/\partial x^2 + \partial^2/\partial y^2$. Then from formula [2], recorded in natural coordinates, author proceeds to make qualitative deductions. Sh. A. Musaelyan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3166. Lebedeva, N. V., Evaluation of the part played by dynamic turbulence in the development of convection (in Russian), *Meteorol. i Gidrologiya* no. 2, 21–26, 1955; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8061.

A simple and convenient method is proposed for the construction of a thermodynamic curve for stratification on an emagram form. This curve is built up in layers indicated in telegrams from pilot balloons. It is possible to judge from the total energy instability the extent of influence of dynamic turbulence on the development of convection movements and by this means to make a diagnosis (and at times even a prognosis) of precipitation of rain.

E. M. Dobryshman

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3167. Slobodov, B. Ya., Calculation of turbulence exchange in the problem of distribution of pressure and wind in the atmosphere (in Russian), *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 8, 1001–1004, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8049.

A generalization is submitted of the problem on the formation of a climatic pressure field, given previously in the works of E. N. Blinov [*Dokladi Akad. Nauk SSSR* **39,** no. 7, 1943] and A. M. Mkhitaryan. The generalization confines itself to considering the effect of the turbulent agitation in a horizontal direction. As a starting point, use is made of the equation of vortex velocity, the equation of continuity and one of the equations of motion, recorded in the spherical system of coordinates. The afore-mentioned equations multiply on the air density and are then integrated along the vertical coordinate z from sea level up to the uppermost boundary of the atmosphere. In the expressions obtained from under the integral sign the mean value of the sub-integral expressions is taken, which is ascribed to an altitude of 4–5 km. The expressions contained in the equations $(\partial\Omega/\partial z)_{z=0}$, $(\partial v_\lambda/\partial z)_{z=0}$, where Ω is the vertical component of the vortex of velocity, v_λ is the latitudinal component of velocity, are determined by the method proposed in Mkhitaryan's paper. The temperature field is assumed to be

known. The solution is sought in the form of a series through spherical functions.

A. S. Mashkovich

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3168. Monin, A. S., Macroturbulent exchange in the earth's atmosphere (in Russian), *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 4, 452-463, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8046.

The characteristics are introduced of large-scale atmospheric turbulence, analogous to those met with in turbulence on a small scale. The expression macroturbulence is meant to convey turbulence on a scale of several hundred kilometers (typical "turbulent elements" are movable cyclones and anticyclones of moderate widths). The characteristics of macroturbulence were determined by charts AT 700 and OT 500/1000 for the period from the 20th of September to the 19th October, 1951. It was established that the coefficient of macroturbulent exchange in the direction of the meridian can be both negative and positive. The values of the coefficient of macroturbulent heat exchange in the direction of the meridian proved to be positive and equal to $5 \times 10^5 \div 10^6$ m²/sec. Values for other turbulence characteristics are given. The author carried out, in addition, a charted weather analysis "index of circulation" for the period from 1st January, 1949 to the 9th April, 1950. The existence of a twelve-day period was established for the fluctuation of the zonal circulation, and also fluctuations, not so clearly defined, with periods approximating 15 and 24 days.

S. A. Mashkovich

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3169. Dunskii, V. F., Influence of the meteorological factor and the vegetation cover on the spread of aerosols in the air (layer) next to the earth (in Russian), *Meteorol. i Gidrologiya* no. 4, 24-28, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8045.

An experimental study is made of the conditions governing the breaking away of the lower edge of a cloud of warmed aerosol spreading in the atmosphere next to the earth. Parallel with the goniometer visual observations of the upper and lower sides of the aerosol cloud, carried out about ten times for each test, meteorological gradient observations were also made. From the data of each test, Richardson's number R_i and the turbulence coefficient K according to Timofeev's formula were determined. The probability A of the breaking away of the cloud was determined as the relation of the number of measurements differing from zero of the lower boundary of the cloud to the general number of measurements of that boundary in the given experiment. Three sets of experiments were carried out: above a flat locality (27 experiments), above crops of millet (18 experiments), and in gardens (6 experiments). The results of the first two sets (of experiments) were identical and contained the following (information): (1) In conditions of convection ($R_i < 0$) the probability of breaking away increases with the intensification of instability, that is with the growth of a negative R_i. The conditions of breaking away advanced by M. I. Budyko [Evaporation in natural conditions; Gidrometizdat, 1948] are well fulfilled. Break-aways of this nature are conditioned by convection movements in the atmosphere on a large scale and are not related to the actual aerosol. Consequently in such conditions it is irrational to use for the treatment of crops either the warmed or the unwarmed aerosol. (2) In conditions of convection ($R_i > 0$), the probability of breaking away increases with the increase of stability, that is with the growth of R_i, or, which is the same thing, with the decrease of K. A break-away of this nature is conditioned by convection movement of the actual aerosol cloud, which contributes a small turbulent heat conductivity to the atmosphere. In such conditions it is irrational to use warmed aerosols but it would be fully justified to apply unwarmed aerosols. (3) In inversion conditions the aerosol cloud after the break-away lifts to a certain height, when further ascent is stopped; in convection conditions the ascent continues right up to the point of dissipation of the cloud. In the third set of experiments (in gardens) the break-away of the aerosol cloud was not observed at all. Author considers that this is conditioned by the extensive roughness of the underlying (earth) surface. In the abstractor's view the cause is to be found in the disintegration by the trees of the turbulent vortices, which in consequence are unable to exercise influence on the significant part of the aerosol cloud.

L. S. Gandin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3170. Mashkovich, S. A., Problem of calculation of vertical currents in the atmosphere (in Russian), *Trudi Tsentr. In-ta Prognozov* no. 43 (70), 29-33, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8035.

To determine the vertical velocity in the atmosphere the equation for the vortex of velocity is made use of. Author records it in terms of spherical coordinates

$$\frac{\partial \zeta}{\partial t} + \frac{v_\theta}{a}\frac{\partial \zeta}{\partial \theta} + \frac{v_\lambda}{a \sin \theta}\frac{\partial \zeta}{\partial \lambda} - \frac{2\omega \sin \theta}{a} v_\theta = \frac{2\omega \cos \theta}{\rho}\frac{\partial \rho w}{\partial z} \qquad [1]$$

where ζ is the vertical component of the velocity vortex, v_θ, v_λ, w are components of velocity along axes θ, λ, z respectively, t is time, ρ density, ω the angular velocity of the rotation of the Earth, a the Earth's radius. In deducing the formulas for the calculation of the vertical velocity the following assumptions are made: (1) The temperature of the air in the troposphere decreases linearly with altitude, while in the stratosphere its value appears as a constant. (2) The vertical velocity in the friction layer is determined by the field of near-earth pressure, that is, it is found by means of A. F. Dyubyuk's known formula [Calculation of vertical velocities along the pressure field, *Tr. NIU GUGMS*, Ser II, 1947, (24)]. The working formula for the calculation of the vertical velocity (in mm/sec), at altitude $H = 5$ km, is put forward by the author in the form

$$w\big|_{z=H} = 0.70 w_b + 0.79 \times 10^{-5} \Delta(\varphi, \bar{\varphi}) + 2.51 \times 10^{-6} [(\bar{\varphi}, \Delta\varphi) + (\varphi, \Delta\bar{\varphi})] - 2.84 \times 10^{-4} \frac{\partial \bar{\varphi}}{\partial \lambda} - 1.53 \times 10^{-4} (\bar{\varphi}, \Delta\bar{\varphi}), \qquad [2]$$

where φ and $\bar{\varphi}$ indicate, respectively, the heights AT_{500} and OT_{1000}^{500}, w_b is the vertical velocity on the upper boundary of friction layer b, while, when computing the corresponding Jacobeans with the aid of end differences, the unit of length is taken to be equal to 1000 km. An example is given for the calculation of the vertical velocity and a comparison is made of the computed rising motion of the air with the position of the zones of fall.

V. V. Bykov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3171. Strokina, L. A., Turbulent heat exchange from the atmosphere and evaporation from the surface of the Baltic Sea (in Russian), *Meteorol. i Gidrologiya* no. 5, 56-60, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8050.

Computations were made of the total monthly flow of heat and evaporation for different parts of the Baltic Sea. The computations were made on the basis of the diffusion formulas of the type of Shuleikin's known formula for evaporation. Coefficient α in these formulas was calculated from the condition of the closing of the equation of the thermal equilibrium of the surface of the whole of the Baltic Sea for a one-year period and by disregarding the yearly totals of heat flow into the water. This coefficient proved to be somewhat larger than its value ascertained earlier for the whole of the oceans of the world. The calculations were made from data collected aboard ship for the period from 1904 to 1932. An exception was the humidity of the air, which was determined,

because of the unavailability of other data, by interpolation from data of shore and island stations. The calculation results are presented in the form of tables of the monthly totals of turbulent heat flow and the consumption of heat by evaporation, and also in the form of charts showing the yearly totals of these quantities. In addition, curves are given of the yearly course of the components of the thermal equilibrium of the total surface of the Baltic Sea as a whole, including the radiation balance and the flow of heat into the water. The analysis of the results obtained led to the following deductions. (1) Calculations of evaporation according to data of shore stations led to completely erroneous results. (2) In the annual course of the components of thermal balance of the surface of the Baltic Sea a basic role is played by the radiation balance and by the flow of heat into the water. They run a parallel course with a summer maximum, when the amplitude of the second (flow of heat into the water) is greater than that of the first, principally on account of the large negative values in winter. (3) The yearly course of the turbulent flow of heat and consumption of heat by evaporation are characterized by their maximum recordings in November and minima (for the turbulent flow negative) in May. (4) In the warm time of the year the turbulent flow of heat and humidity alters very slightly on the surface of the Baltic Sea, while in the cold period, the variation is stronger; in consequence, the spatial changes in the yearly totals of these flows are principally determined by the changes of amplitude in the cold (winter) half year. L. S. Gandin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3172. Kogan, S. Ya., Method of calculation for the advective inflow of heat (in Russian), *Trudi Geofiz. In-ta Akad. Nauk SSSR* no. 37 (164), 132–156, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8069.

A method is proposed for the calculation of the changes of temperature conditioned by horizontal transfer. The temperature field in the region surrounding the point for which the determination of advection of heat is being made approximates (in value) to that of a polynomial of the second order. In addition axis x takes the direction along the flow; the beginning of the coordinate is situated in the point for which the calculation is being made. The coefficients of the approximated polynomial are found by the method of the smallest squares. The temperature advection is calculated as the product of the value of the wind velocity in the point being investigated and the value $\partial T/\partial x$ when $x = 0$, $y = 0$. This value in the given case is equal to the coefficient at x in the polynome referred to. The calculation scheme is fully demonstrated; two examples are given. S. A. Mashkovich

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3173. Shvets, M. E., Condensation of water vapor in the atmosphere (in Russian), *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 6, 547–551, 1955; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8076.

The problem is investigated of the condensation of water vapor in the presence of turbulent exchange. As a starting point the equations of transmission of water vapor and inflow of heat are used on the assumption that the coefficients of turbulent exchange for humidity and for heat are equal. It is assumed that, in the region under investigation, the water vapor reaches the condition of saturation. In this case the absolute humidity appears as a function of temperature only. Making use of this fact and by applying unessential simplifications of the original system of equations, author obtains a formula for the quantity of water which separates out per unit of time and unit of volume. In conformity with this formula the quantity of condensed humidity depends, principally, on the vertical motion of the air, the vertical temperature gradient and the derivative on the vertical coordinate from the coefficient of turbulent agitation. Boundary conditions are formulated for the migrating (or immovable) surface separating the region of saturated air from the region with humid unsaturated air. A formula is deduced for the velocity of migration of the above-mentioned surface. S. A. Mashkovich

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Book—3174. Final report of the Advisory Committee on Weather Control. Volumes I and II, Washington 25, D. C., U. S. Government Printing Office, 1958; Volume I, xii + 32 pp., Volume II, x + 422 pp.

The first volume is a cautiously optimistic summary of the Advisory Committee's evaluation of experiments on artificial stimulation of precipitation. Principal conclusion is that seeding of winter-type storm clouds in mountainous areas in western United States produced an average increase in precipitation of 10 to 15%, but that no significant effect could be detected in other areas. The second volume contains detailed technical reports on statistical evaluation, physical evaluation, legal situation, special studies, and a comprehensive bibliography on weather modification and cloud physics. These reports have a wide range of importance and accuracy. Among the most interesting are those on statistical evaluation, which explore the problem of detecting a small, artificially induced effect on a highly variable quantity in a limited number of experiments where very little control is possible. The difficulties in this problem emphasize the note of caution in the optimism of Volume I. J. E. Miller, USA

Book—3175. Berlyand, M. E., Forecasting and arrangement of the thermal regime of the atmospheric layer next to the earth (in Russian), Leningrad, Gidrometeoizdat, 1956, 435 pp., 18 r.; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10626.

The book consists of three parts: I. Regular nature of the thermal system and the forecasting of temperatures in the atmospheric layer next to the earth; II. Transformation of air masses; III. Arrangement of the thermal regime of the atmospheric layer next the earth.

In part I, an investigation is made of the nonstationary changes in air and soil temperatures, described by equations of heat conductivity, in which the coefficient of thermal conductivity is assumed to be constant for the soil, increasing linearly with altitude in the air layer adjoining the earth, and constant above this layer. A general solution is given for the thermal conductivity equation when suitable initial and boundary conditions are in operation, and is is shown that changes in temperature in the air layer next the earth can be taken approximately as being quasi-stationary. It is explained how it is possible to determine the air temperature by means of the temperature of the underlying surface and the temperature of the soil by means of the air temperature. Then the information regarding the radiation equilibrium of the underlying surface is set out, the means available for calculating the effective radiation are investigated in detail, and an evaluation made of radiation heat exchange in the air. A theory is developed in a simplified, but apparently sufficiently accurate, way of the diurnal (24-hr) sequence of temperatures, turbulent exchange and radiation balance. Information is furnished of the critical temperatures (during periods of frost) for a number of cultivated plants, and, based on the general formulas obtained and referred to previously, a method is worked out for the precalculation of the nocturnal fall in temperature and the forecasting of night frosts, with a large quantity of experimental data introduced in support. By joint solution of the equation of heat conductivity and the equation of diffusion of aqueous vapour, an investigation is carried out of the problem of evaporation and condensation of humidity on the underlying surface. Information is produced on the observed quantities of dew formation and its influence on temperature and humidity of the air is gaged. The conditions governing the formation of radiation

mists are examined and a method is proposed for their precalculations.

In part II the first matter examined is the nonstationary transformation (that is the changes in and distribution of temperature and humidity) of moving air masses, for which purpose, in the equations of heat conductivity and diffusion of aqueous vapour utilized in part I, convection terms are added. A general solution of the equations is found with the aid of a double Laplace conversion (by time and by the horizontal coordinate). The solutions obtained are simplified and are put forward in the form of

$$\Delta T = a\Delta R + b\Delta T_0, \quad \Delta P = c\Delta R + d\Delta T_0$$

where ΔT, ΔP are the differences in values of the temperature and of the turbulent thermal flow in the moving air mass and at the initial point; ΔR, ΔT_0 are the differences in the radiation balance and in the temperature at the initial and given points in the initial moment of time; a, b, c, d are coefficients, depending on the conditions of transformation, which may be recorded in tabular form. A comparison of the results of the calculations by the proposed formulas with the data of the synoptic observations shows satisfactory agreement. A special case is analyzed concerning the transformation of air masses of small movement. Computations are made for the influence wielded by the initial distribution of the temperature and also for the 24-hr behavior of the radiation balance. The steady process of transformation of moving air masses is investigated. Further, the problem is solved of the nonstationary changes of temperature in the air layer next the earth, when thermal advection is active; this merges with the joint solution of the equations for thermal conductivity in the air layer adjoining the earth (taking into account the convection item) and in the soil. Here the coefficient of turbulent temperature conductivity in the air layer next the earth is taken in the form of a power function of the height with an arbitrary indicator. The solution is found, as shown above, in a double Laplace conversion, which is most convenient for giving effect to the proved simplications in this or that boundary case. The solution is obtained for a constant wind velocity with altitude; for estimating the influence of the change in wind velocity with altitude a simplified problem is examined, in which use is made of the quasi-stationary state of the air layer next the earth, while the wind velocity is taken in the form of a power function of the altitude with an arbitrary indicator. The results obtained are used for the calculation of the 24-hr variations in temperature when thermal advection is present.

In part III an examination is made of the methods of open heating of plants in danger from night frosts, and matters are considered such as the computation of the thermal balance of the heaters, the temperature field in their vicinity, their efficiency and the normal consumption of fuel. Then attention is given to ways and means of protecting the plants from frost by smoke screens. The relevant calculations necessitate the joint solution of the equation of smoke diffusion and of the equation for thermal conductivity, in which consideration is given to the thermal effects of humidity condensation on smoke particles, to the effect of weakening of thermal radiation in the smoke-laden atmosphere (and, also as a boundary condition, the reduced efficiency of the earth's radiation) and to the effect of the separation of heat into the sources of the smoke. The calculations carried out are enriched by experimental data and enable a set of practical recommendations to be drafted. A. S. Monin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3176. Cooley, D. S., Statistical forecasting operators based on dynamical equations, *Tellus* **10,** 3, 331–341, Aug. 1958.

Multiple regression equations are evaluated which relate the 12- and 24-hour changes in 500 and 1000 mb height to (a) the existing 500 mb and 1000 mb heights at 15 points, (b) certain quadratic functions of these heights which appear in the dynamical equations used for numerical weather forecasting. Seventy to 80% of the observed variance of 500 and 1000 mb height changes are accounted for.

The addition of the more complicated predictors ((b) above) adds only a little to the prediction value of the regression equations. However, it cannot be deduced that the quadratic terms are dynamically unimportant because their effect may already have been largely taken into account by the regression on the linear predictors ((a) above). J. S. Sawyer, England

3177. Benton, G. S., Some comments on the numerical integration of the vorticity equation and related equations, *Tellus* **10,** 3, 313–325, Aug. 1958.

Author shows that it is sufficient to specify only the streamfunction over the boundaries of an Eulerian region in order to achieve a unique, continuous solution of the nonlinear vorticity equation. Overspecification of boundary conditions is discussed and admissible solutions defined. Specification of vorticity in addition to streamfunction at inflow boundaries leads to internal discontinuity surfaces which propagate into the region. Different methods of numerical integration are investigated in respect to a particular nonlinear first-order differential equation for which the analytical solution is known. It is shown that stable numerical solutions exist, in contradiction to the deductions from linear theory. Author concludes that the stability criteria developed by Platzman for a linear system cannot be applied to a nonlinear system. Results indicate that a re-evaluation of current practices of numerical integration is in order.

Reviewer considers the reading of this paper a must to all those concerned with numerical integration. R. O. Reid, USA

3178. Klyncharev, S. S., Utilization of extrapolating formulae as targets for prognosis of migration of barometric (isobar) centers (in Russian), *Meteorol. i. Gidrologiya* no. 3, 26–28, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8070.

Starting from the known Pettersen formulas for the velocity of travel of barometric centers and assuming that this velocity is a constant in the course of a day, author proposes a simple way of precalculation for the future dispositions of cyclone and anticyclone centers. A formula is given for the calculation of the cyclone velocity component parallel to the straight line, passing through the corresponding centers of the fall and rise of pressure. The other velocity component is not taken into account. The calculation is achieved according to the pressure data and the general tendency, but only in two points—in the isollobaric foci. Results are stated of the comparison of the given method with that proposed earlier by L. S. Gandin and K. K. Sinel'nikov [*Meteorol. i. Gidrologiya* no. 3, 28–30, 1955], where the calculation is made on the data of four points lying on the axes of an ellipse, depicting the isobars. For twenty cases investigated, the prognosis error for the location of the cyclone center for a day using the given method of calculation was on average 200 Km less than when the calculation was made for four points. It has to be noted that the proposed method of calculation gives the best results in those cases where the baric formations move without appreciable change of intensivity, while the isollobaric foci are not spaced too far apart.

S. L. Belousov

Courtesy Referativnyi Zhurnal, USSR
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Naval Architecture and Marine Engineering

(See also Revs. 2803, 3094)

3179. Cutland, R. S., Velocity measurements in close proximity to a ship's hull, *N. E. Cst. Instn. Engrs. Ship. Trans.* **74,** 6, 341–356, Mar./Apr. 1958.

Evaluation of skin-friction coefficients for three-dimensional flow such as that existing on ship and ship-model hulls has so far defied practical solution. Author describes experiments made in the laboratory and on full-scale ships at sea to measure velocity distribution in the boundary layer and to compute local friction resistance coefficients from the experimental data. Boundary-layer velocity profiles were measured with pitot rakes on friction planes in a towing tank and on two ships.

Computed local friction coefficients showed considerable variation in values and led to conclusion that use of boundary-layer surveys to obtain local friction coefficients which in turn could be integrated for whole ship is not feasible.

Author's experiments were very carefully carried out and produced data of scientific interest; however, they were of limited scope and do not in themselves completely verify the conclusion reached. R. B. Couch, USA

3180. Tick, L. J., Certain probabilities associated with bow submergence and ship slamming in irregular seas, *J. Ship Res.* **2,** 1, 30–36, June 1958.

Paper presents the first successful combination of Pierson's description of random sea, and of Korvin-Kroukovsky's linear ship motion equations, with the Szebehely slamming conditions [AMR **10** (1957), Rev. 359]. The most significant offspring of the skillfully and elegantly executed marriage of these subjects is a method which furnishes predictions for the number of slams as a function of the sea state and ship parameters.

The validity of application of the linear equations describing the pitching and heaving motions of a ship to sea conditions associated with slamming is questionable. It has been shown [AMR **5** (1952), Rev. 3606] that the slamming accelerations do not influence significantly the velocity or displacement characteristics of the ship's motion; nevertheless, the linear theory has a tendency to overestimate the amplitudes of heave and pitch. This might be one reason why the author's equations furnish rather high slamming frequencies.

Evaluation of the formulas given in the paper regarding the more complete theory, extension to 10% aft the fore foot impact, generalization to a well-defined critical impact velocity, comparison with experimentally obtained irregular slamming in regular waves [AMR **10** (1957), Rev. 301] and slamming force, acceleration and bottom pressure calculations, are items still awaiting the author's skillful treatment.

Paper is one of the most significant contributions to the field of ship slamming. V. G. Szebehely, USA

3181. de Witt, H., Theory of initial lateral stability of straight hydrofoils as a function of lift distribution along the span, Parts I and II (in German), *Schiffstechnik* **4,** 23, 220–224, Sept. 1957; **4,** 24, 289–294, Oct. 1957.

So far a simple geometrical method has been used to determine the initial transverse stability. Author shows that this procedure is valid for rectangular lift distribution over the span only and gives the solution for an arbitrary distribution. Continuing the reasoning due to Horn, the influence of the transverse force due to inclination is studied for initial and steady conditions. A special investigation is devoted to divided foils. General results are illustrated by examples. G. P. Weinblum, Germany

3182. Emerson, A., Roughness and scale effect on propellers, *Intern. Shipbldg. Progr.* **5,** 43, 136–138, Mar. 1958.

3183. St. Denis, M., and Craven, J. P., Recent contributions under the Bureau of Ships fundamental hydromechanics research program, Part I. Introduction; Part II. Powering, *J. Ship Res.* **2,** 2, 1–36, Oct. 1958.

Friction, Lubrication and Wear

3184. Bowden, F. P., and Freitag, E. H., The friction of solids at very high speeds. I. Metal on metal; II. Metal on diamond, *Proc. Roy. Soc. Lond.* (*A*) **248,** 1254, 350–367, Nov. 1958.

Very high relative speeds up to 1800 miles/hr (800 m/s) between rubbing surfaces occur in special circumstances such as between a shell and the driving band in a gun barrel or between rocket-driven sledges on rails. Authors investigated friction of a ball spinning *in vacuo* when trapped between three symmetrically arranged plates. The friction was deduced from the deceleration of the ball, and the surface damage suffered by the contacting surfaces was investigated by electron-microscopy.

Using steel balls, the behavior of copper, pure aluminum, duralumin, bismuth, antimony, molybdenum and tungsten was studied. Generally the sliding resistance increased as the speed decreased, until seizure occurred at low speeds. The low friction at high speeds was due to frictional heating causing softening and melting of the metal at the regions of contact. Metal transfer occurred in practically all instances and indications of intermetallic diffusion were observed when mutual solubility of the metal pair existed, e.g. tungsten-steel.

Similar experiments were carried out with steel balls decelerated by the octahedral faces of three flat diamond surfaces. Deceleration from very high speeds (600 m/s) caused transfer of metal to the diamond surface and a correspondingly high coefficient of friction (~ 0.2). Latter suddenly dropped to ~ 0.05 when a speed of ~ 200 m/s was reached. At this stage considerable wear of diamond occurred due to allotropic transformation into graphite or amorphous carbon. No surface damage of diamond was observed when decelerating the ball from a speed of 100 m/s.

L. Grunberg, Scotland

3185. Bowden, F. P., and Scott, H. G., The polishing, surface flow and wear of diamond and glass, *Proc. Roy. Soc. Lond.* (*A*) **248,** 1254, 368–378, Nov. 1958.

Authors investigated the effect of rotating glass disks (7-in. diam) at speeds up to 5000 rpm under rigidly mounted diamond slider. Loads ranged from 250 g to 4 kg. A pointed diamond caused scratching of the glass surface which increased in severity with increasing loads and speeds. A smooth diamond on abraded glass surfaces gave negligible wear at low speeds. Above a critical speed, v_c, depending on the load W and on the type of glass used, smooth wear tracks were obtained suggestive of viscous surface flow. A relationship $v_c\, W^{1/2} = \text{const}$ was found to apply. Thermal softening explains the observations and may occur on a submicroscopic scale when glass is polished.

Wear measurements were carried out on specially shaped diamonds after sliding on glass. In dry air wear may be one hundred times greater than in the presence of atmospheric humidity. Diamond seems to wear through degradation to amorphous carbon, but not through oxidation. L. Grunberg, Scotland

3186. Milne, A. A., Experiments on the friction and endurance of various surface treatments lubricated with molybdenum disulphide (in English), *Wear* **1,** 2, 92–103, Oct. 1957.

Annular rings of mild steel were rotated in contact until seizure occurred. Untreated, phosphated and sulphided surfaces in association with four different molybdenum disulphide formulations were tested and the results presented in the form of friction and endurance. The results illustrate the variation of friction and endurance with the magnitude of the applied load and demonstrate the beneficial action of both the phosphate and sulphide pre-treatments. From author's summary

3187. Seal, M., The abrasion of diamond, *Proc. Roy. Soc. Lond.* (*A*) **248,** 1254, 379–393, Nov. 1958.

Paper investigates the mechanism whereby material is removed during the abrasion of diamond with diamond dust. It has previously been suggested that wear occurred through the removal of small blocks or through attrition on an atomic scale. Author considers the possibility of a thermal abrasion mechanism, but had been unable to confirm a previous suggestion that oxidation, i.e. the burning of frictional hot-spots, took place. Thermal degradation to amorphous carbon may be important. Author investigated friction and surface damage by sliding a hemispherically ended diamond stylus on polished diamond surfaces. Friction and abrasion resistance are dependent on the orientation of the crystal lattices. Orientations of high friction are least abrasion-resistant. Heavy loads of the order of several kgs with sliders having radii of several hundred micron produce definite tracks, which contain ring cracks otherwise known to be produced by sufficient static loading of brittle materials. In the present sliding experiments the cracks result from tensile stresses. In addition, the center of the tracks may show heavy damage. Ring cracks are associated with low friction, and heavy damage in the center of the tracks with high friction. Author attempts a quantitative interpretation of the observations.

L. Grunberg, Scotland

3188. Borsoff, V. N., On the mechanism of gear lubrication, *Trans. ASME* **81D** (*J. Basic Engng.*) no. 1, 79–93, Mar. 1959.

Paper is a brief review of the research on fundamentals of gear lubrication performed at Shell Development Company for the Bureau of Aeronautics of the Department of the Navy. Scoring and wear of gears are evaluated as functions of various operating variables, gear geometry and construction factors, and lubricants properties. This is followed by a brief discussion of the results of experiments performed with tagged extreme pressure lubricants showing distribution and thickness of the extreme pressure films and the rates of their attrition. Based on all of these results, a mechanism of gear lubrication is postulated and discussed.

From author's summary

3189. Wakuri, A., and Ueno, T., On the lubrication of worm gears, *Bull. JSME* **1**, 2, 189–193, June 1958.

The gearing motion of worm gears is characterized by sliding. To obtain worm gears of high performance, therefore, it is essential to make the actual contact area large enough by finishing them precisely, and to exercise special care in the design, manufacture and assembling in order that the lubricant may diffuse evenly all over the contact area. Authors tested the performance of actual worm gears by means of the power circulating worm-gear testing machine and made it clear that the entry gap and the running-in were very important. Authors also clarified that worm gears were in action under the condition of boundary lubrication.

From authors' summary

3190. Fischer, G. K., Cherubim, J. L., and Fuller, D. D., Some instabilities and operating characteristics of high-speed gas-lubricated journal bearings, ASME Ann. Meet., New York, N. Y., Nov.-Dec. 1958. Pap. 58-A-231, 12 pp.

Various factors influencing the stable operation of high-speed rotors on gas-lubricated journal bearings have been isolated, such as critical speed, unbalance, film stiffness, whirl, damping, and air hammer. Experimental data are given for a number of bearings to illustrate the effects of these factors on operation of gas-lubricated bearings and correlation to mathematical analysis. The isolation and understanding of these factors have been due primarily to the instrumentation developed. Rotor assemblies on ½ and ¾-in.-diam shafts have been run successfully on hydrostatic and hydrodynamic air bearings at speeds up to 165,000 rpm.

From authors' summary

3191. Jakobsson, B., and Floberg, L., The rectangular plane pad bearing (in English), *Trans. Chalmers Univ. Technol.* no. 203, 44 pp., 1958.

A numerical evaluation is made of the flow in a thin oil film between a plane surface and a sliding, rectangular pad of finite dimensions. The partial differential equation of the theory of lubrication is transformed into a difference equation, which is then solved by using an electronic computer. Solutions are obtained for several values of the pad width-length ratio and of the oil-film thickness. Results, presented in form of charts and tables, include the pressure distribution in the oil, load capacity of the bearing, load location, oil flow, power loss, friction coefficient and temperature rise. A procedure for optimum design of rectangular plane pad bearings is developed on the basis of these results.

M. Hanin, Israel

3192. Yamamoto, T., On critical speeds induced by ball bearings at lower rotating speeds, *Bull. JSME* **1**, 3, 240–244, Aug. 1958.

When single-row radial ball bearings are used, several critical speeds take place in a vertical shaft at certain rotating speeds lower than the major critical speed. When the bearing center line of both bearing pedestals is not in alignment and the shaft is not in a perfectly straight line, there is the possibility that these critical speeds occur. The frequencies of vibrations of these critical speeds are represented by $z\omega_i$, $z\omega_i + 1$ and $z\omega_i - 1$, where ω_i is the precessional rotating speed of balls in bearing and z is the number of balls. The whirling motions of these critical speeds are those of both forward and backward precessions.

When self-aligning double-row ball bearings are used, these critical speeds do not occur; they occur only in the shaft supported by single-row radial ball bearings.

From author's summary

Books Received for Review

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INDEX OF AUTHORS REFERRED TO IN THIS ISSUE

(NUMBERS USED ARE SERIAL NUMBERS OF REVIEWS)

Aboav, D. A. 2829
Agnew, J. T. 3093
Al-Arabi, M. 3076
Amakasu, T. 2916
Ambrose, T. W. 3077
Amdur, I. 3065
Ames, J. S. 2771
Anderson, G. E. 3024
Andreae, C. 3153
Aramanovich, I. G. 2900
Arutyunian, N. Kh. 2812
Asanuma, T. 2981
Assmus, F. 2966
Avanessov, V. T. 3148
Axelrad, D. R. 2838
Babalyan, G. A. 3147
Baechler, R. H. 2949
Baker, R. M. L., Jr. 3118
Balavadze, V. K. 2910
Barshtein, I. K. 3097
Barta, J. 2808
Basch, A. 2779
Basilievitch, V. 2801
Batin, N. A. 3130
Beckwith, I. E. 3081
Beedle, L. S. 2950
Belley, G. A. 2873
Bellman, R. E. 2757, 2782
Belyayev, B. I. 2864
Benton, G. S. 3177
Berezantsev, V. G. 2818
Berlyand, M. E. 3175
Bernhardt, E. C. 2977
Bhargava, R. N. 2846
Bhatnagar, P. L. 3103
Bilby, B. A. 2830
Blatherwick, A. A. 2923
Bogorodskii, V. V. 3123
Bolz, R. W. 2897
Bomberger, H. B. 2948
Bones, J. A. 2837
Borsoff, V. N. 3188
Boteler, W. C. 3080
Bowden, F. P. 3184, 3185
Boym, A. A. 2799, 2800
Breckenridge, J. R. 2766
Bressler, R. 3085
Brown, G. W. 2803
Bryant, R. A. A. 2768
Buchwald, V. T. 2881
Bueche, F. 2936
Buell, C. E. 3159
Bufler, H. 2875
Bugaenko, G. A. 3044
Bullen, N. I. 3162
Buneman, O. 3100
Bychawski, Z. 2810
Cadwell, D. E. 2903
Carafoli, E. 3030
Carpenter, L. H. 2992
Cartwright, D. E. 3154
Carwile, N. L. 2931
Casey, R. S. 2940
Chadwick, P. 2883
Chalmers, B. 2827
Chatterjee, B. B. 2796
Chertock, G. 3094
Chertousov, M. D. 2984
Cherubim, J. L. 3190
Chetaev, N. G. 2878
Chetty, S. M. K. 2846, 2847
Chilton, H. 2996
Chobanian, K. S. 2812
Clarke, J. H. 3002
Clarkson, J. 2854
Clutter, D. W. 3049
Cochran, D. L. 2998
Cohen, N. B. 3008
Collatz, L. 2756
Conway, H. G. 2785
Cooley, D. S. 3176
Corcos, G. M. 3124
Covert, E. E. 3104
Crancher, D. W. 2928
Craven, J. P. 3183
Crisp, J. D. C. 3107
Crossland, B. 2837
Cushing, V. 3053
Cutland, R. S. 3179
Czarnecki, J. T. 3083
Czyzak, S. J. 2828
Davis, S. 2790
Dawance, M. G. 3152
DeBell, A. G. 3069
Devienne, F. M. 3010
de Witt, H. 3181
Diaconis, N. S. 3057
Dmitrevsky, A. A. 2970
Dobrowolski, A. 3112
Dodge, D. W. 2979
Douglas, D. A. 2914
Doussin, L. 2976
Dragan, C. 2968
Drazin, P. G. 3079
Dressler, R. F. 3039
Duff, A. D., Jr. 3087
Duff, R. E. 3009
Duffy, J. 2879
Dumer, A. B. 3090
Dunskii, V. F. 3169
Durstine, R. M. 2755
Dzhordzhio, V. A. 3157
Eickner, H. W. 2975
Eid, A.-R. 2860
Emerson, A. 3182
Emmons, H. W. 3091
Emtsev, V. T. 2985
Engel, J. N. 3059
Engquist, R. D. 2906
Eresenkov, N. I. 3128
Eschenback, R. C. 3093
Fabri, J. 3005
Facaoaru 2935
Fainzil'ber, A. M. 3017
Fedyaevskii, K. K. 3020
Fenain, M. 3004
Feola, N. 2926
Feughelman, M. 2813
Findley, W. N. 2919
Fine, B. 3092
Finkelstein, D. 3102
Fischer, G. K. 3190
Fisher, M. E. 2761
Fleischer, R. L. 2826, 2827
Floberg, L. 3191
Flugge, S. 2753
Franke, P. G. 2991
Freese, C. E. 2874
Freitag, E. H. 3184
Frenkiel, F. N. 3028
Frossling, N. 3086
Fujie, K. 3047
Fujimoto, T. 3137, 3138, 3139, 3140
Fuller, D. D. 3190
Fusner, G. R. 2930
Gakkel' 2868
Galustian, S. B. 2870
Gardner, L. R. T. 2830
Garvey, B. S., Jr. 2939
Gary, J. H. 3126
Gayle, J. B. 3126
Gazarian, Iu. L. 3119
Gebelein, H. 3026
Geil, G. W. 2931
Gemmerling, A. V. 2858
Ginevskii, A. S. 3020
Ginsburg, T. 3043
Glicksberg, I. 2782
Godridge, A. M. 3082
Gofflin, A. P. 3046
Gol'dberg, Z. A. 3121
Gotovtsev, V. I. 3055
Gould, L. A. 3089
Greenspan, D. 2767
Greiner, J. H. 2828
Grinberg, S. M. 2869
Grishanin, K. V. 3131
Groenig, H. 3105
Gross, D. 3070
Gross, O. A. 2782
Grove, C. S., Jr. 2940
Grubin, A. N. 2811
Guillot, R. 2861
Hansen, A. G. 3012, 3013
Hansen, T. C. 2934
Harris, I. 3116
Harris, S. L. 2967
Harrison, W. B. 3080
Hartnett, J. P. 3115
Hartunian, R. 3023
Heil, M. 3021
Heller, J. T. 2974
Henri, M. 2888
Herrick, S. 3118
Herzig, H. Z. 3012
Heyman, J. 2851
Hodge, E. D. 2790
Hoffman, G. A. 2932
Hoffmann, Sh. M. 2863
Hopkes, U. 2999
Hopp, Yu. A. 2969
Horejsi, J. 2835, 2840
Horne, M. R. 2957, 2958
Horst, R. L. 2937
Hsu, S. T. 3063
Ichiye, T. 3155
Ignaczak, J. 2804
Ihrig, D. 3161
Inoue, Y. 2907
Ionescu, M. 3030
Ionov, V. N. 2849
Iosifov, M. N. 2913
Itaya, S. 3127
Jackson, T. W. 3080
Jahnke, W. E. 2929
Jakobsson, B. 3191
Jastrow, R. 3116
Johnson, W. 2899
Jones, H. 2924
Jorgensen, S. M. 2837
Kachanov, L. M. 2859
Kaegi, E. M. 3057
Kalman, R. E. 2784
Kapanyan, L. K. 2962
Kaplan, W. 2754
Karapetian, B. K. 2880
Karapetyan, K. S. 2815
Karlsson, S. K. F. 3019
Kartashov, V. A. 2798
Kartvelishvili, N. A. 2983
Katsuhara, T. 2995
Katz, E. J. 3141
Kawakami, K. 2973
Kawasaki, T. 2927
Keintzel, E. 2807
Keller, H. B. 2758
Kempner, J. 2865
Kennard, E. H. 2781
Kestin, J. 2933
Kita, Y. 2927
Klier, E. P. 2926
Klimov, N. I. 2858
Kline, S. J. 2998, 3042
Klyncharev, S. S. 3178
Knudsen, J. G. 3077
Kobatake, Y. 2907
Koepcke, R. W. 2784
Koga, T. 3056
Kogan, S. Ya. 3172
Kosterin, E. V. 2889
Kostitsyn, V. T. 2834
Kotzegubov, V. P. 2922
Kovalev, Ya. T. 2988
Kozarov, M. 2866
Kozhevnikova, V. N. 2802
Krein, S. G. 2773
Krishnamurthy, E. V. 2760
Krivosheyin, V. F. 3046
Kryzhanovskaya, T. A. 2892
Kuenzi, E. W. 2929
Kuznetsov, V. D. 2831
Lacey, O. L. 3126
Lamm, M. M. 2901
Laue, K. 2839
Lawrence, H. R. 3041
Lazan, B. J. 2923
Lebedeva, N. V. 3166
Lehrian, Doris E. 3110
Leiderman, Yu. R. 2871
Lennon, J. W. 2938
Leo, B. S. 3063
Lermond, D. S. 3072
Lester, R. H. 3125
Levi, I. I. 3129
Levin, B. I. 3090
Lieberman, P. 3117
Liepmann, H. W. 3078

INDEX OF AUTHORS REFERRED TO IN THIS ISSUE *(Continued)*

(NUMBERS USED ARE SERIAL NUMBERS OF REVIEWS)

Lifson, M. W. 2788
Lightfoot, E. 2960
Lighthill, M. J. 3014
Lilic, B. S. 2986
Lin, C. C. 3098
Lin, T. H. 2828
Lin, Y.-K. M. 2857
Lind, J. E., Jr. 3072
Lipayev, Yu. A. 3144
Litwiniszyn, J. 3011
Livesley, R. K. 2759
Lockwood, R. M. 3032
Loitsianskii, L. G. 3027
Lopatin, B. V. 2819
Lotkin, M. 3071
Luce, W. A. 2946
Lunc, M. 3068
Luu, T.-S. 2765
Lykoudis, P. S. 3101
Lyman, P. T. 2803
MacIntosh, R. M. 2947
MacMillan, W. D. 2770, 2772
Macovsky, M. S. 3111
Malkin, I. G. 2778
Min-Yuan, M. 2844
Mangeron, D. 2968
Marke, P. W. 2997
Marron, A. J. 2943
Marrone, P. 3023
Marsden, D. J. 3031
Marstrand J. 2997
Martemyanov, A. I. 2964
Martin, J. A. 3064
Martin, W. A. 3058
Mashkovich, S. A. 3170
Mason, E. A. 3065
Mateescu, Cr. 2990
Matveenko, T. I. 3145
Mayo, A. P. 3048
McDonald, W. J. 2903
McMahon, H. M. 3025
Medvedev, S. V. 2965
Melik-Asslanov, L. S. ...3148
Mellgren, A. 2816
Mercier, R. 3136
Meriam, J. L. 2769, 2803
Mertsalov, A. N. 3165
Metzner, A. B. ...2978, 2979
Meyer, C. A. 3064
Meyer zur Capellen, W. .2971
Miele, A. 3034, 3113
Mihai, I. P. 2952, 2954
Mikeladze, M. Sh. 2856
Miljenko, B. 2959
Milne, A. A. 3186
Mindlin, R. D. 2879
Mironov, V. D. 3095
Mochizuki, M. 3163
Moiseev, N. N. 2774
Mollo-Christensen, E. ..3108
Molyneux, W. G. 3106
Monin, A. S. 3168
Morduchow, M. 3022
Morikawa, S. 2918
Moskvitin, V. V. ..2821, 2876
Moszynski, J. M. 2933
Mott, N. F. 2924
Mucskai, L. 3088
Mukharinskaya, I. A. ...3147
Mullarkey, E. J. 2941
Mundo, C. J. 2789
Murakami, M. 2877
Murnaghan, F. D. 2771
Murphy, J. S. 3049
Nakamura, H. 2916
Nazarov, N. T. 3050
Nelsson, L. E. 2921
Nemirovskii, Ya. M. 2843
Netrebko, V. P. 2809
Neuber, H. 2875
Neumark, S. 3033
Newhouse, D. L. 2930
Nordby, G. M. 2917
Norris, C. B. 2974
Nowacki, W. 2794
Nowinski, J. 2855
Oakley, J. 2898
Obodovsky, B. A. 2797
Oki, I. 2973
Olszak, W. 2817
Orlenko, G. P. 2911
Ouchida, H. 2915
Ovsonyan, K. Kh. 2989
Owaku, S. 2918
Panasyuk, V. B. 2806
Paoletti, A. 3029
Papillo, M. A. 3036
Parthasarathy, M. R. ...2847
Pasternak, P. L. 2894
Pavlik, E. 2786
Payne, H. 2828
Peacock, J. H. 2946
Perry, C. W. 3096
Perzyna, P. 2817
Petrasen, G. I. 2885
Petrov, V. V. 2783
Philip, J. R. 3151
Phillips, R. A. 2908
Pilatovsky, V. P. 3150
Plainevaux, J. E. 2904
Podstrigatch, Ya. S. 2806
Popov, B. A. 3132
Powley, M. B. 3001
Pridmore-Brown, D. C. .3120
Prins, J. E. 3040
Priss, L. S. 2833
Pritchard, J. L. 3037
Probine, M. C. 2764
Rabinovich, B. V. 3133
Rahz, W. E. 3054
Rainbird, W. J. 3031
Ramachandran, G. N. ..2760
Rama Reddy, K. 3045
Ramaswamy, G. S. 2845, 2846, 2847
Rant, Z. 3061
Ranz, W. E. 3054, 3134, 3141
Rasskazovskii, V. T. 2836
Razumova-Sretenskaya, V. N. 3143
Reddy, R. B. 3041
Red'ko, S. G. 2905
Reichel, A. 2838
Rigby, B. J. 2814
Rivkin, S. L. 3067
Roberts, L. 3074
Robertson, A. F. 3070
Rogozinski, Marian 2791
Roots, O. T. 2762
Rosciszewski, J. 3016
Rosenberg, R. M. 3035
Rozenblyum, V. I. 2848
Rubin, M. M. 3097
Russo, A. 3023
Rutkovskii, V. Yu. 2783
Ryabova, E. V. 2886
St. Denis, M. 3183
Sakagami, J. 3163
Sakurai, T. 2927, 3000
Sanjo, S. 3127
Sawa, N. 2981
Sawyer, G. A. 3102
Saydov, P. I. 2780
Scala, S. M. 3007
Schwartz, E. W. 3075
Scofield, F. 2945
Scott, C. J. 3024
Scott, H. G. 3185
Seal, M. 3187
Seth, B. R. 2805
Seymour, R. B. 2944
Shaffer, D. H. 2755
Shekhter, O. Ya. 2893
Shekhter, Ya. N. 3164
Shengeliya, P. G. 2787
Sherman, Pauline M. ...3056
Sherwood, E. M. 2942
Sherwood, J. W. C. 2872
Shield, R. T. 2824
Shikhaliev, F. A. 2891
Shimotake, H. 3066
Shinn, D. A. 2925
Shtalev, B. A. 2850
Shvets, M. E. 3173
Siestrunck, R. 3005
Silvestri, G. J. 3064
Simmons, F. S. 3069
Simon, R. 2902
Simpson, R. W. 3031
Simvoulidi, I. A. 2841
Singer, S. F. 3114
Sirota, A. M. 3067
Slisskii, P. M. 2985
Slobodov, B. Ya. 3167
Smith, J. C. 3072
Smith, Marie Madden ..2912
Smith, P. L., Jr. 3052
Smolovik, I. I. 2793
Sneddon, I. N. 2883
Soliom, I. 3088
Sololov, V. I. 2852
Soo, S. L. 3060
Southwell, R. V. 2763
Stamm, A. J. 2949
Stanculaescu, G. 2935
Steidel, R. F. 2803
Steketee, J. A. 2909
Stepanov, R. D. 3109
Stevens, L. K. 2963
Stix, T. H. 3099
Stott, T. C. F. 2920
Strasser, G. 2961
Stratton, T. F. 3102
Streeter, V. L. 2982
Stroh, A. N. 2830
Strokina, L. A. 3171
Suchar, M. 2853
Svenson, E. 3026
Swindeman, R. W. 2914
Takata, M. 2882
Takenaka, T. 3127
Talbot, L. 3056
Tanaka, S. 3122
Tarassenko, E. N. 2820
Tarassenko, I. I. 2820
Tassi, G. 2953
Taylor, W. B. 3135
Terminasov, Yu. S. 2832
Theodorides, P. J. 2795
Thodos, G. 3066
Thurlow, G. G. 3082
Thwaites, H. L. 2766
Thyagarajan, C. 3003
Tick, L. J. 3180
Timofeef, M. P. 3156
Tixier, M. P. 3146
Togunov, Yu. V. 2884
Tooher, E. W. 2789
Toryanik, M. S. 2862
Trbojevic, B. 2955
Trimpi, R. L. 3008
Trofimovich, V. V. 2823
Troskolanski, A. T. 3051
Tsibulsky, G. P. 3149
Tsikunov, V. A. 3158
Tsitskishvili, A. R. 3142
Tsytovich, N. A. 2895
Tumura, M. 2776
Turnacliff, R. D. 3115
Tuzov, L. V. 2832
Tyabin, N. V. 2980
Ueda, S. 2916
Ueda, T. 2994
Ueno, T. 3189
Ushkalov, V. P. 2890
Vaisman, M. D. 3062
Vallee, Denise 3004
Val'ter, L. L. 2822
van Winkle, M. 3052
Varvak, P. M. 2792
Vicentini, M. 3029
Viggiano, A. 2926
Vinogradov, A. I. 2951
Vinokur, M. 3006
Vitale, A. J. 3057
Vodonik, J. L. 2940
Volvich, S. I. 2972
Wakuri, A. 3189
Wallis, J. 3082
Wang, C. J. 3041
Ward, G. T. 3084
Warren, W. R. 3057
Weisbecker, H. L. 2903
Weiss, V. 2926
Wentworth, R. C. 3114
Weymann, H. D. 3105

(Continued on outside back cover)

INDEX OF AUTHORS REFERRED TO IN THIS ISSUE *(Continued)*

(NUMBERS USED ARE SERIAL NUMBERS OF REVIEWS)

Williams, J. C., III 3015
Williamson, K. I. 3135
Wilson, E. E. 3087
Wood, R. H. 2956
Woodcock, A. H. 2766
Worley, W. J. 2825
Wroth, C. P. 2887
Yamamoto, T. 3192
Yarema, S. Ya. 2806
Yaropolsky, I. V. 2896
Yen, K. T. ..2993, 3003, 3018
Yff, J. 3038
Yohner, Peggy L. 3013
Young, A. D. 3033
Yushchenko, A. A. 2867
Zakkay, V. 3073
Zhamagortsyan, V. N. ..2989
Zhuravlev, P. A. 2987
Ziegler, H. 2824
Ziemba, S. 2775
Zlamal, M. 2777
Zlokovic, D. 2842